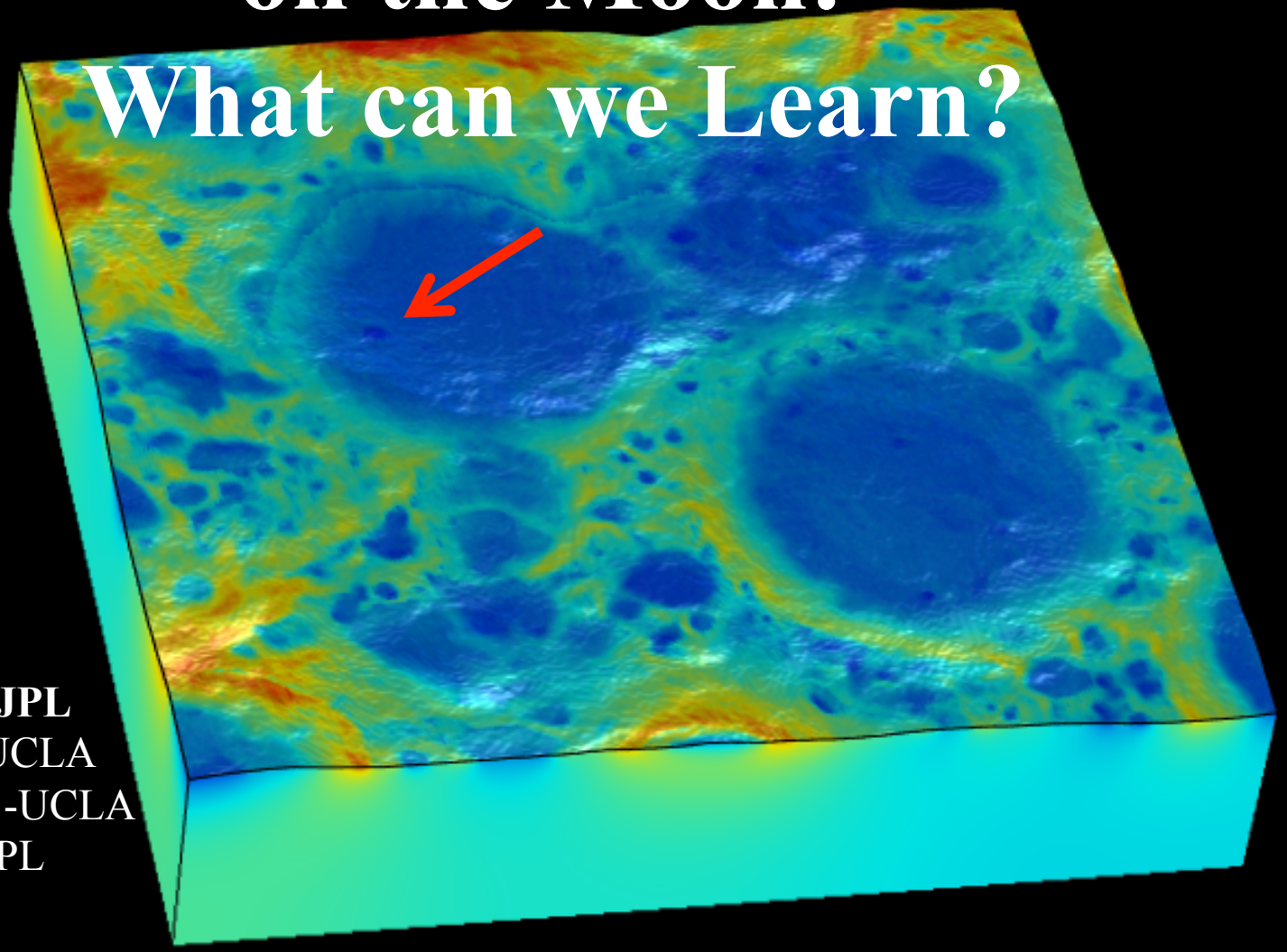
The Lowest Temperatures on the Moon:

What can we Learn?



Matt Siegler – JPL
David Paige – UCLA
Pierre Williams -UCLA
Sue Smrekar –JPL
Diviner Team

This Talk:

1) A brief reminder of temperatures on the Moon

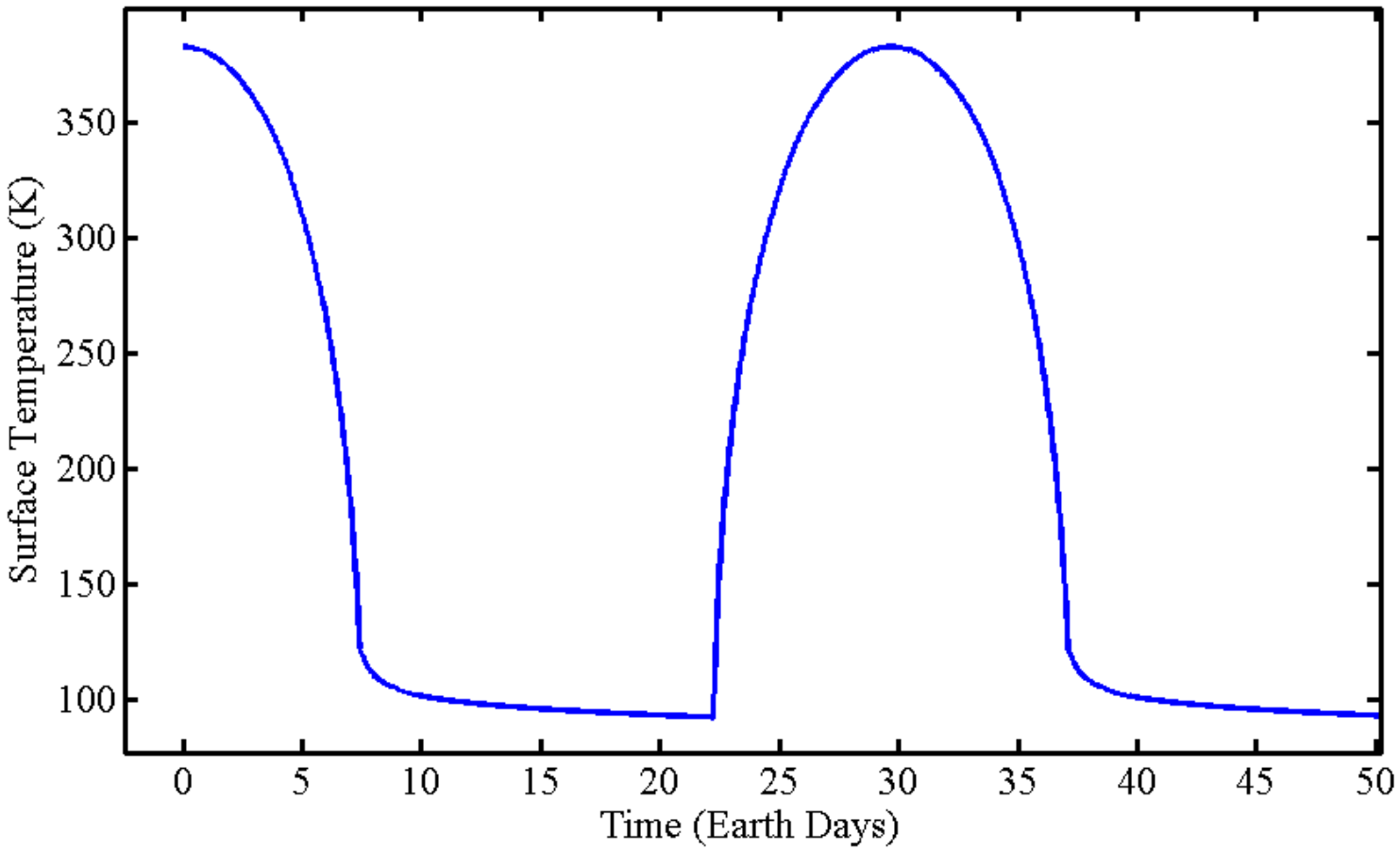
2) Temperature extremes- New data in cold places

3) What do they tell us?
   - Geothermal Heat Flow?
   - A new regime of thermal properties?
   - Strange things brewing in polar coltraps?

4) Progress and current lines of attack.

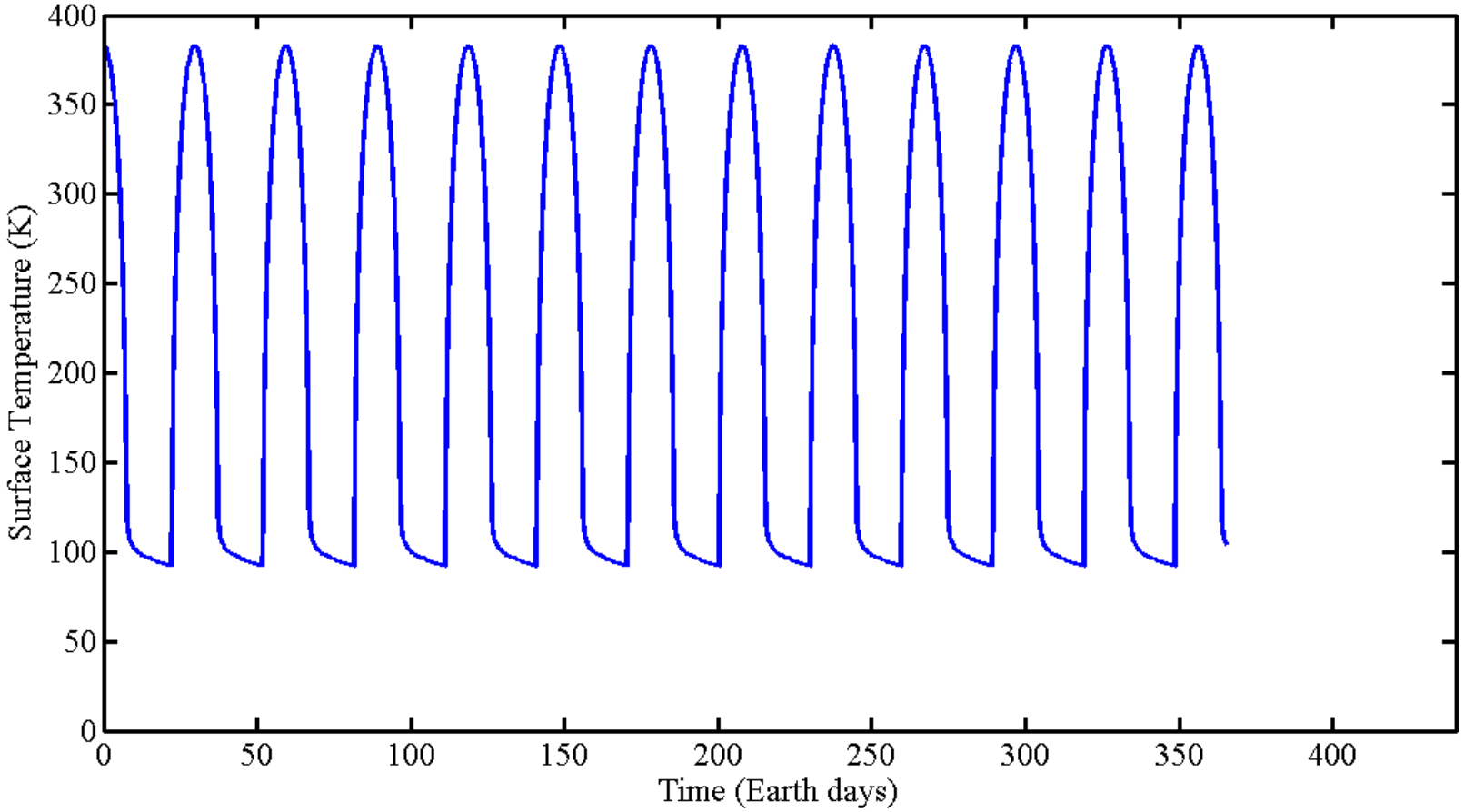
1) The basics:

Equatorial Temperatures



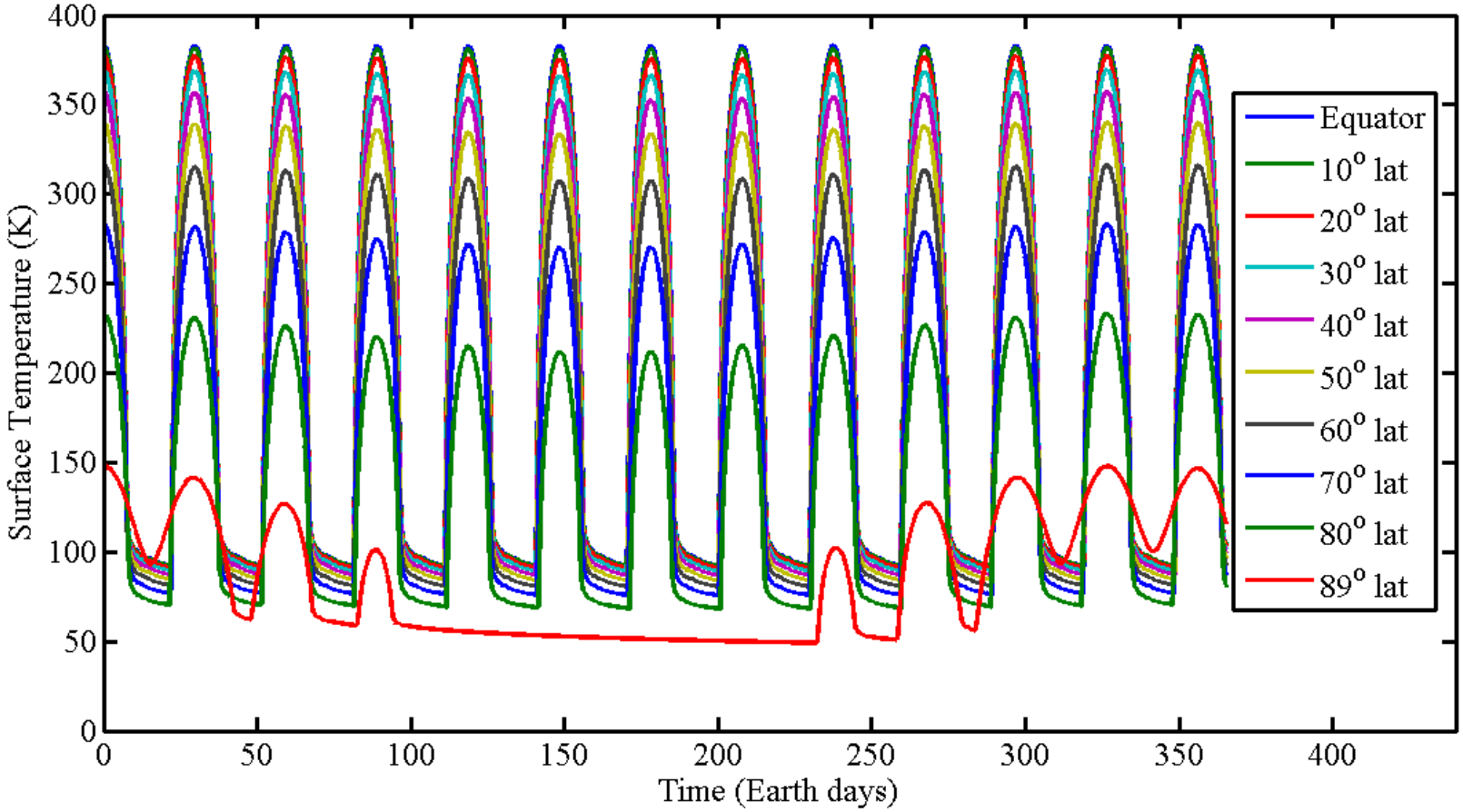
1) The basics:

Equatorial Temperatures



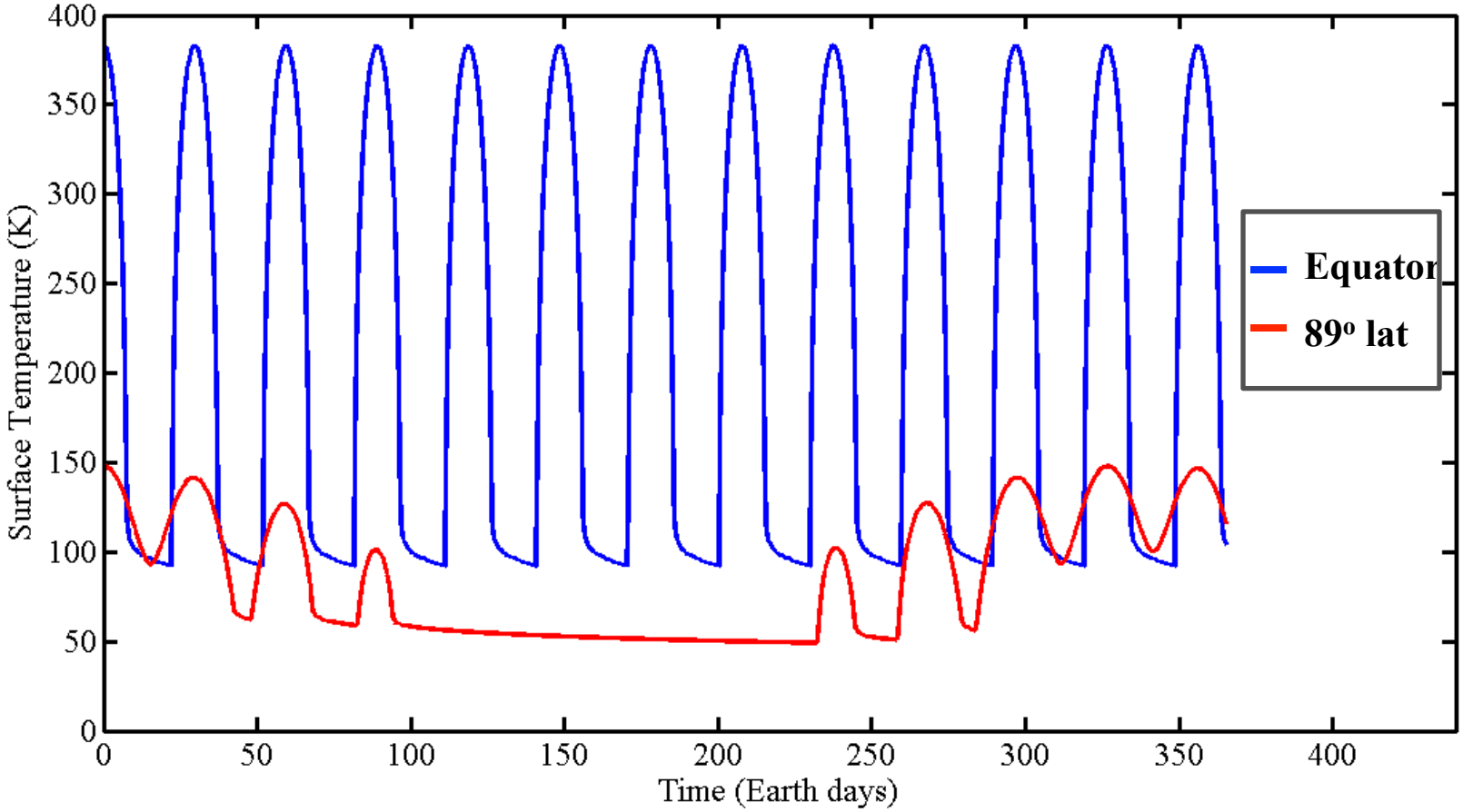
1) The basics:

Global Temperatures



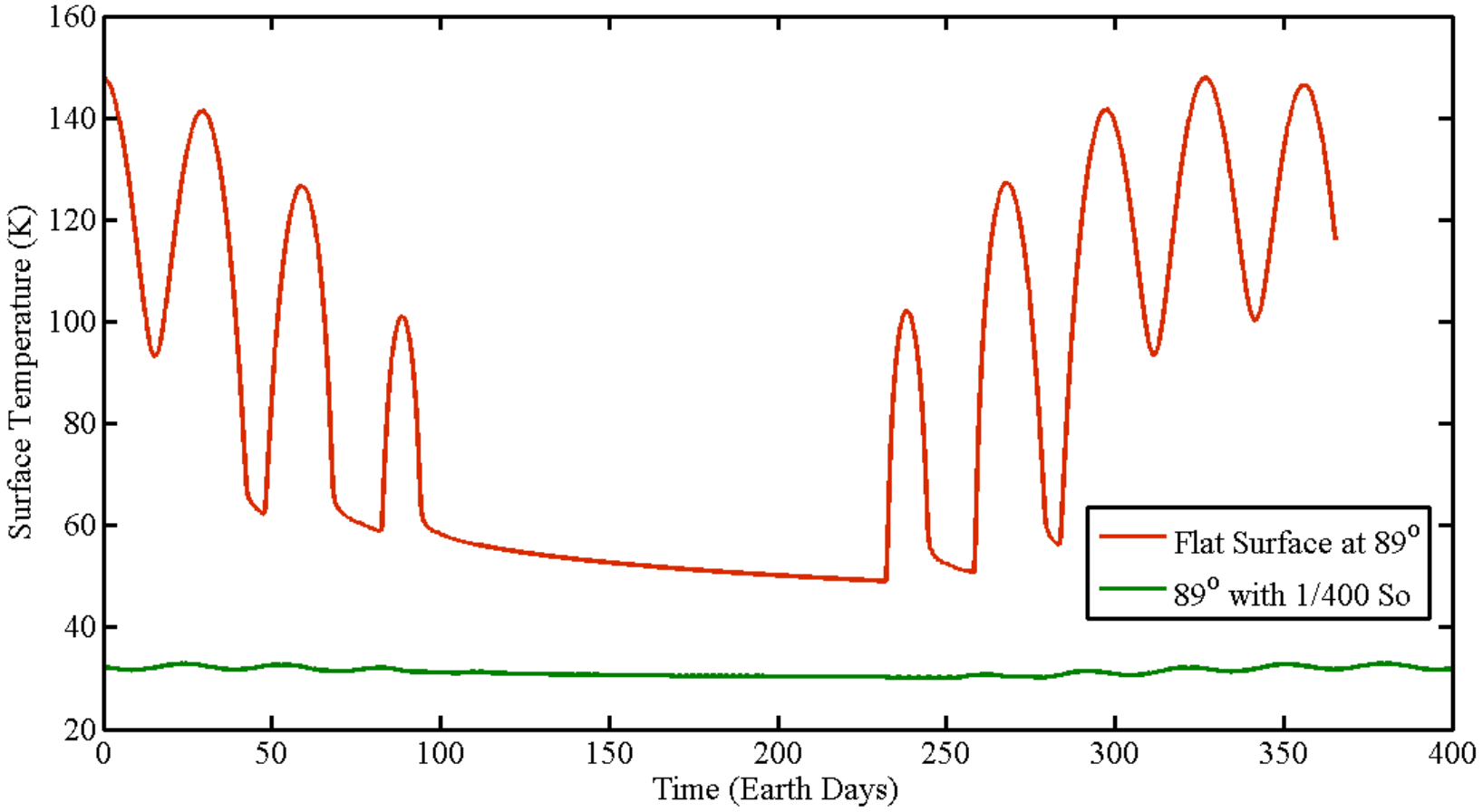
1) The basics:

Extreme Temperatures



1) The basics:

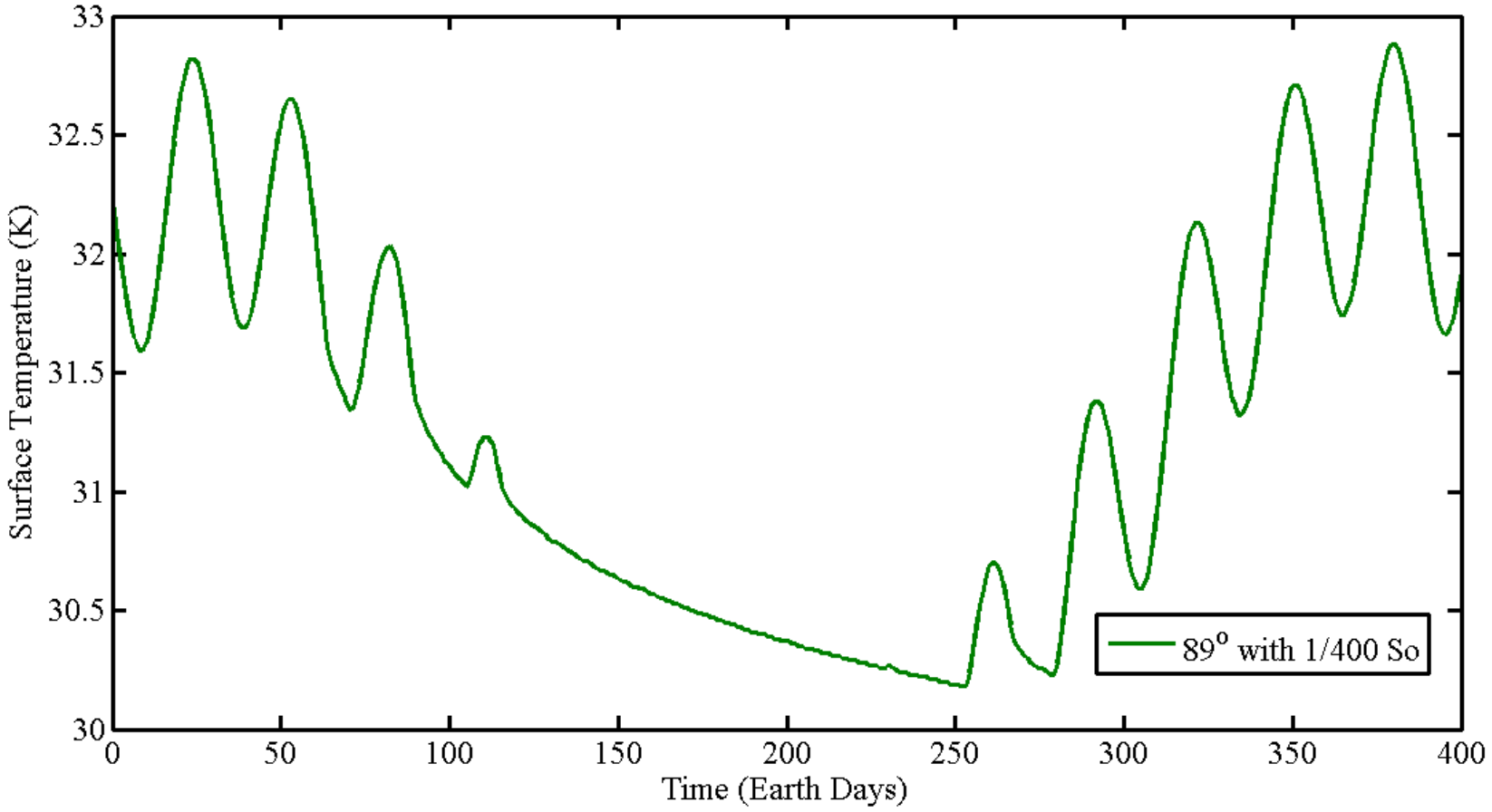
More extreme Temperatures



Imagine a crater within a crater with 1/400th solar input,
…the equivalent of putting the Moon at 20 AU

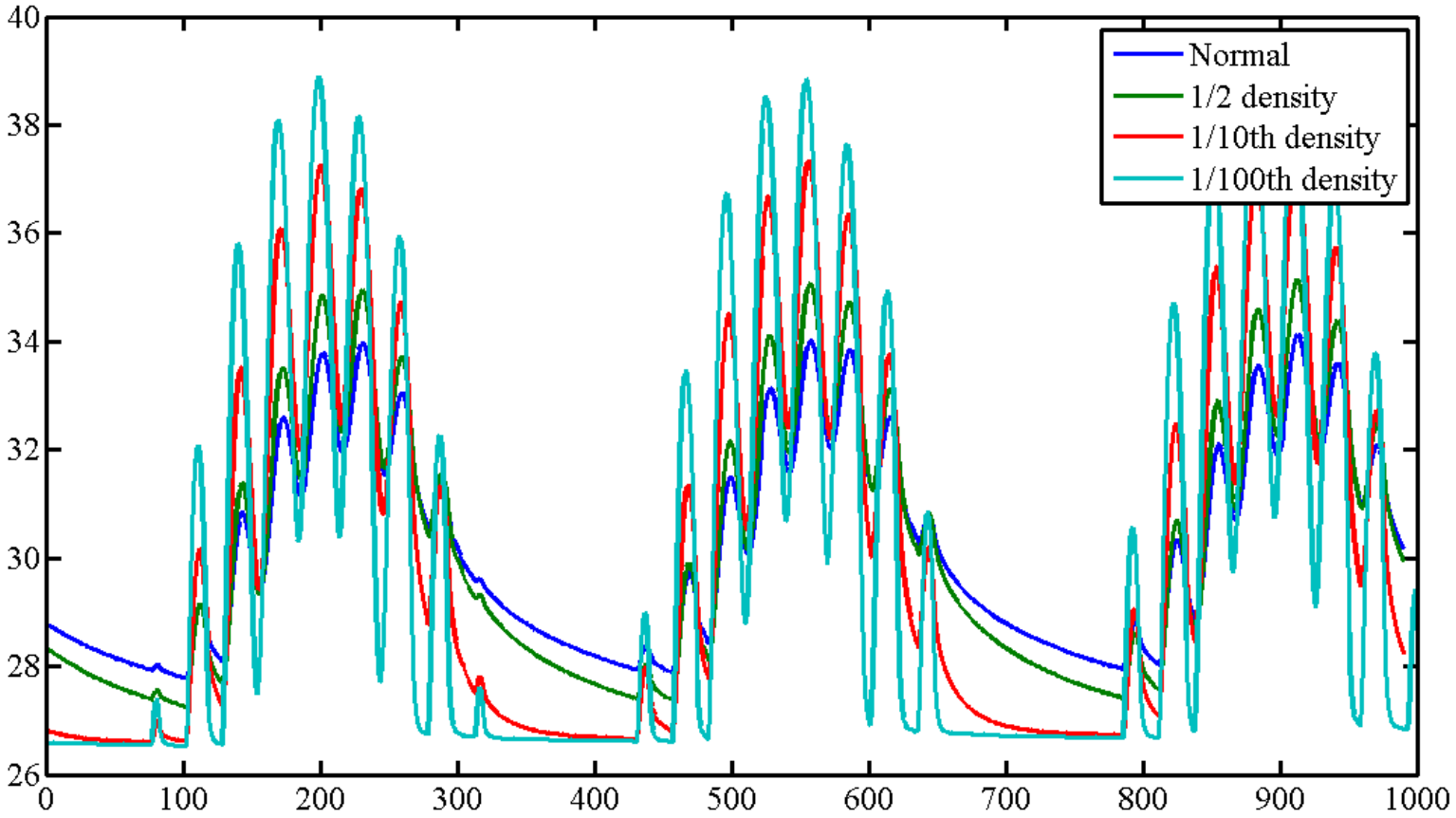
1) The basics:

Damn, that's cold.



1) The basics:

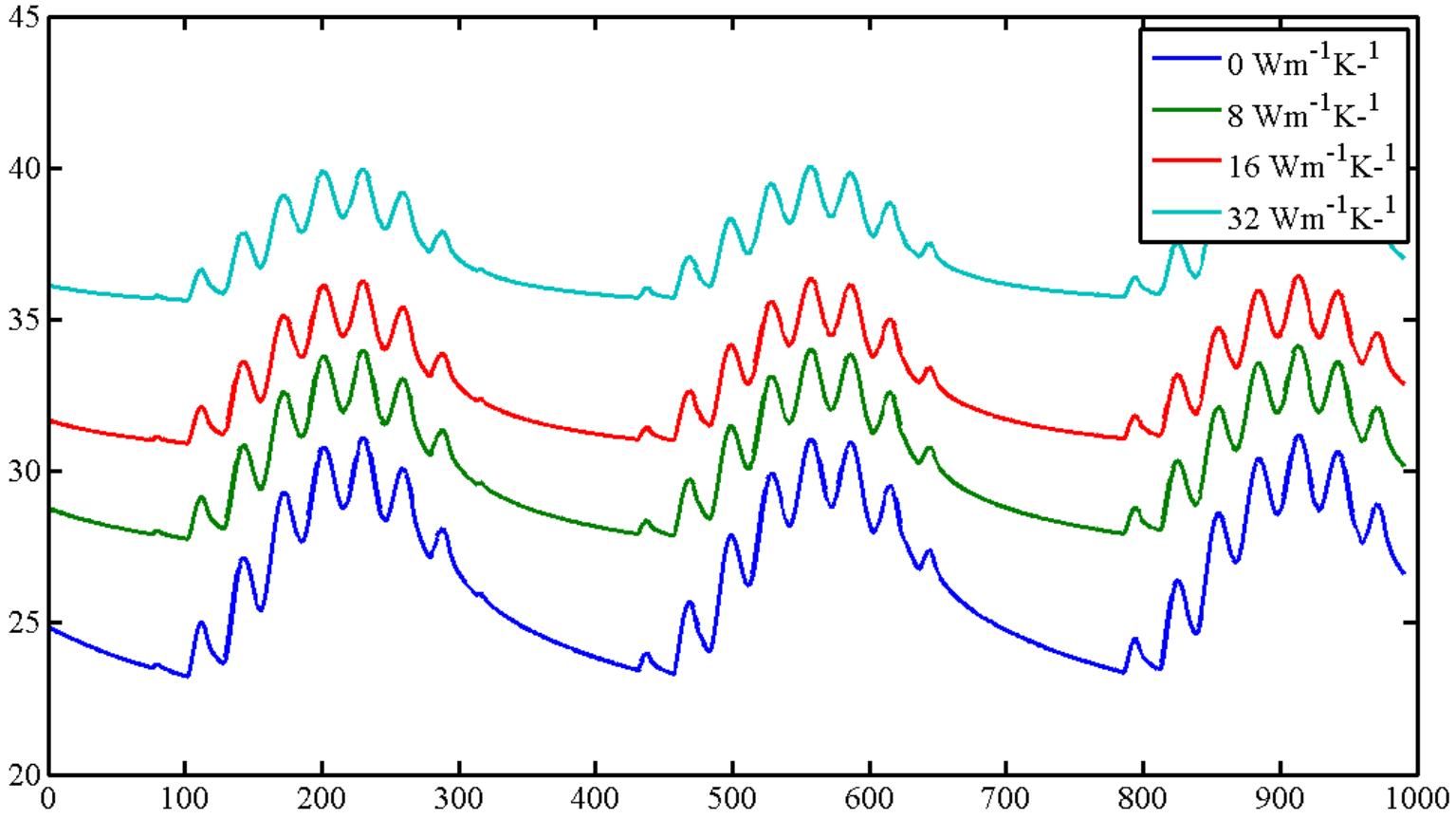
What things can effect how cold it gets?



Thermal inertia (here proxied by changing density)

1) The basics:

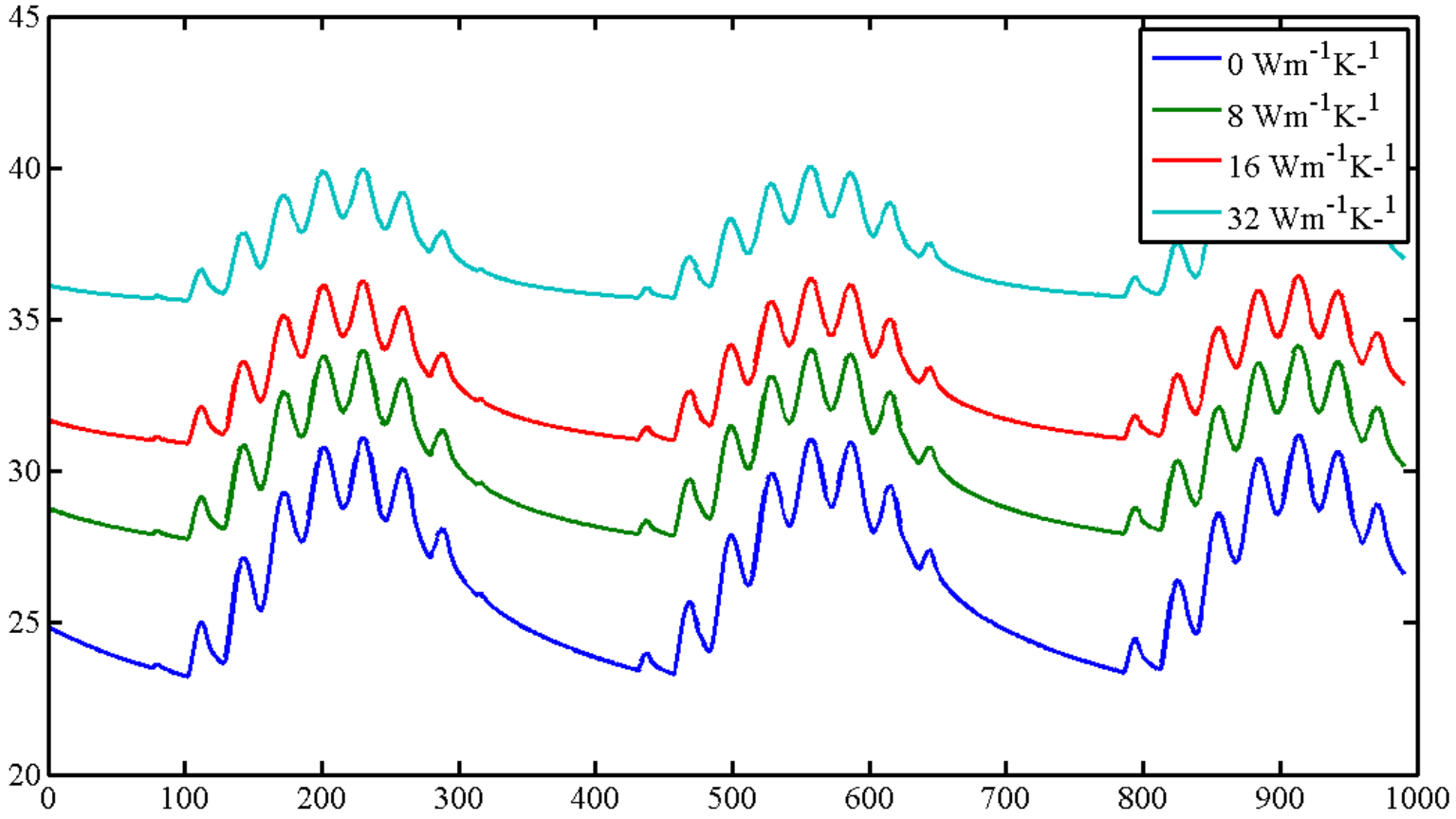
What things can effect how cold it gets?



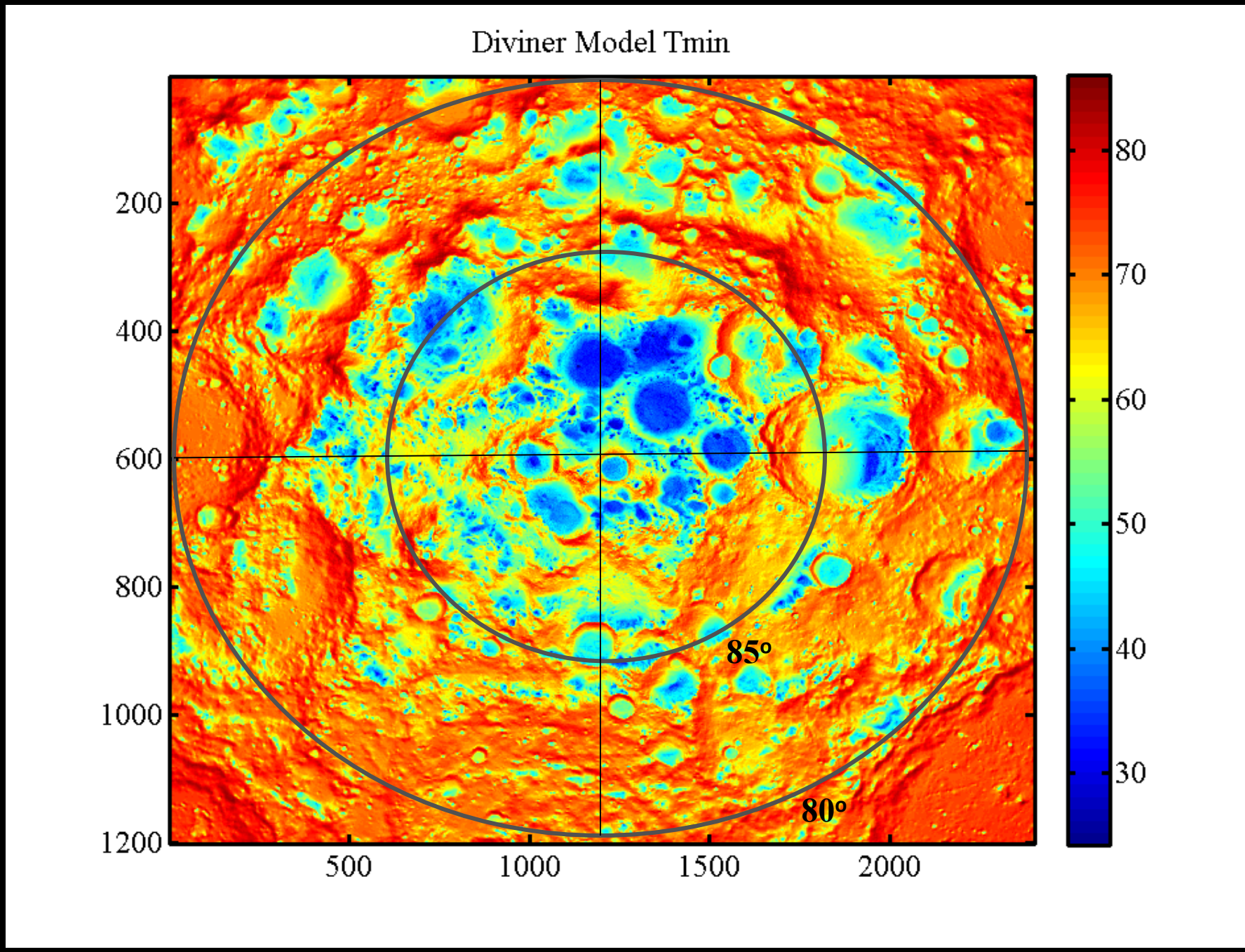
My personal favorite: Geothermal heat flow

1) The basics:

Too bad things couldn't possibly get that cold on the Moon…



~ 40 K was the coldest expected measurement during instrument development


Diviner Model Tmin
200
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600
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1000
1200
500
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2000
85°
80°
80
70
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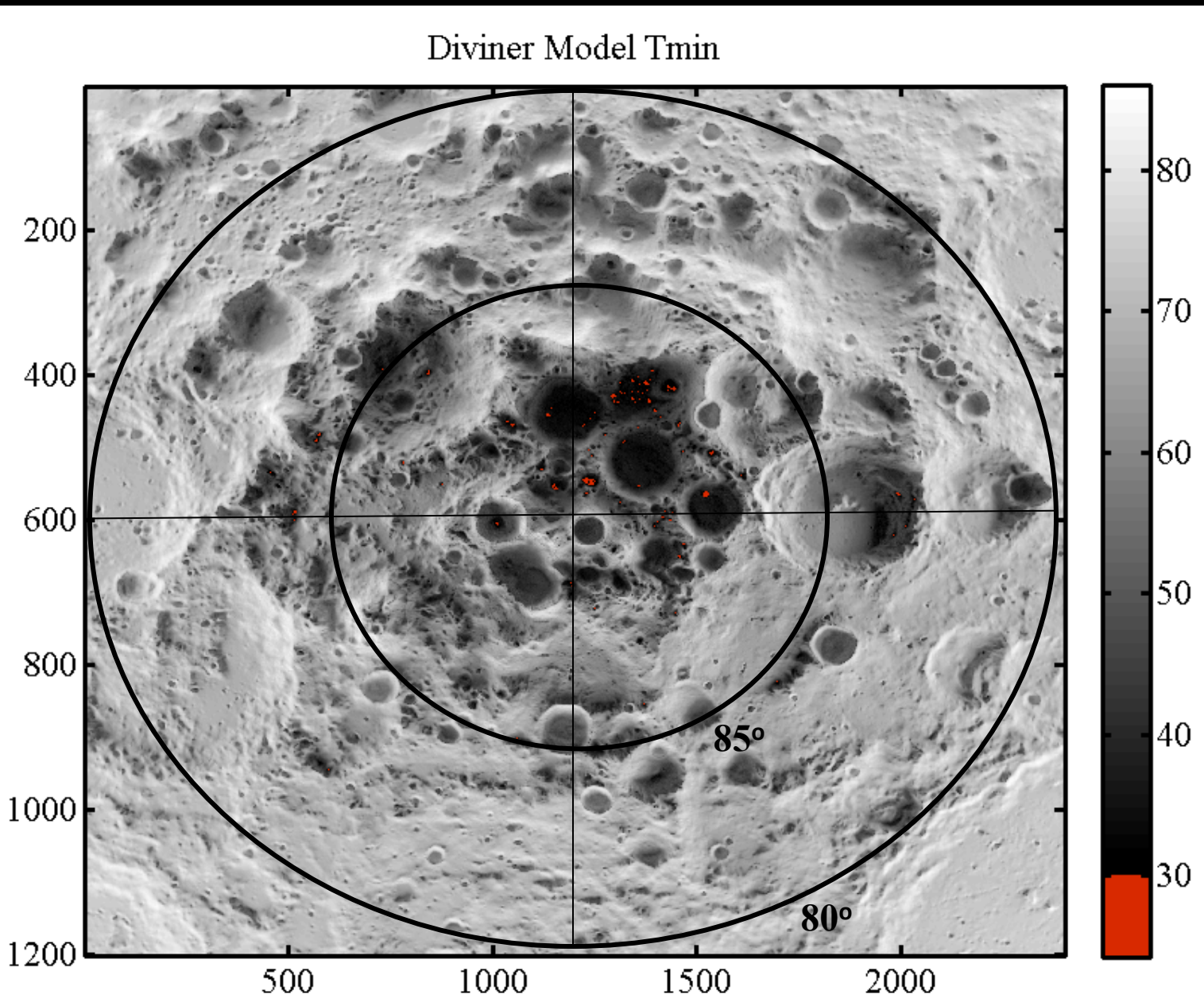
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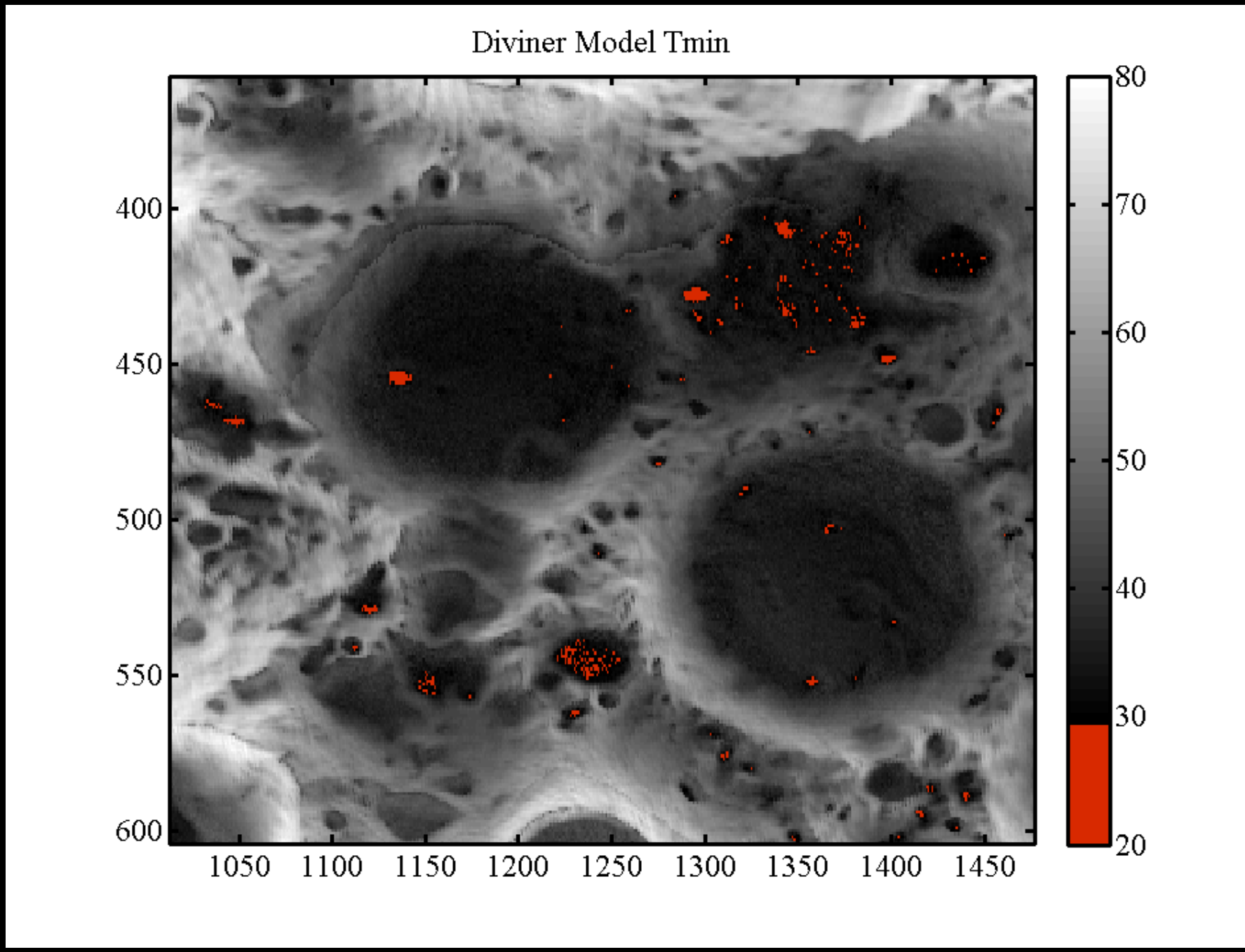
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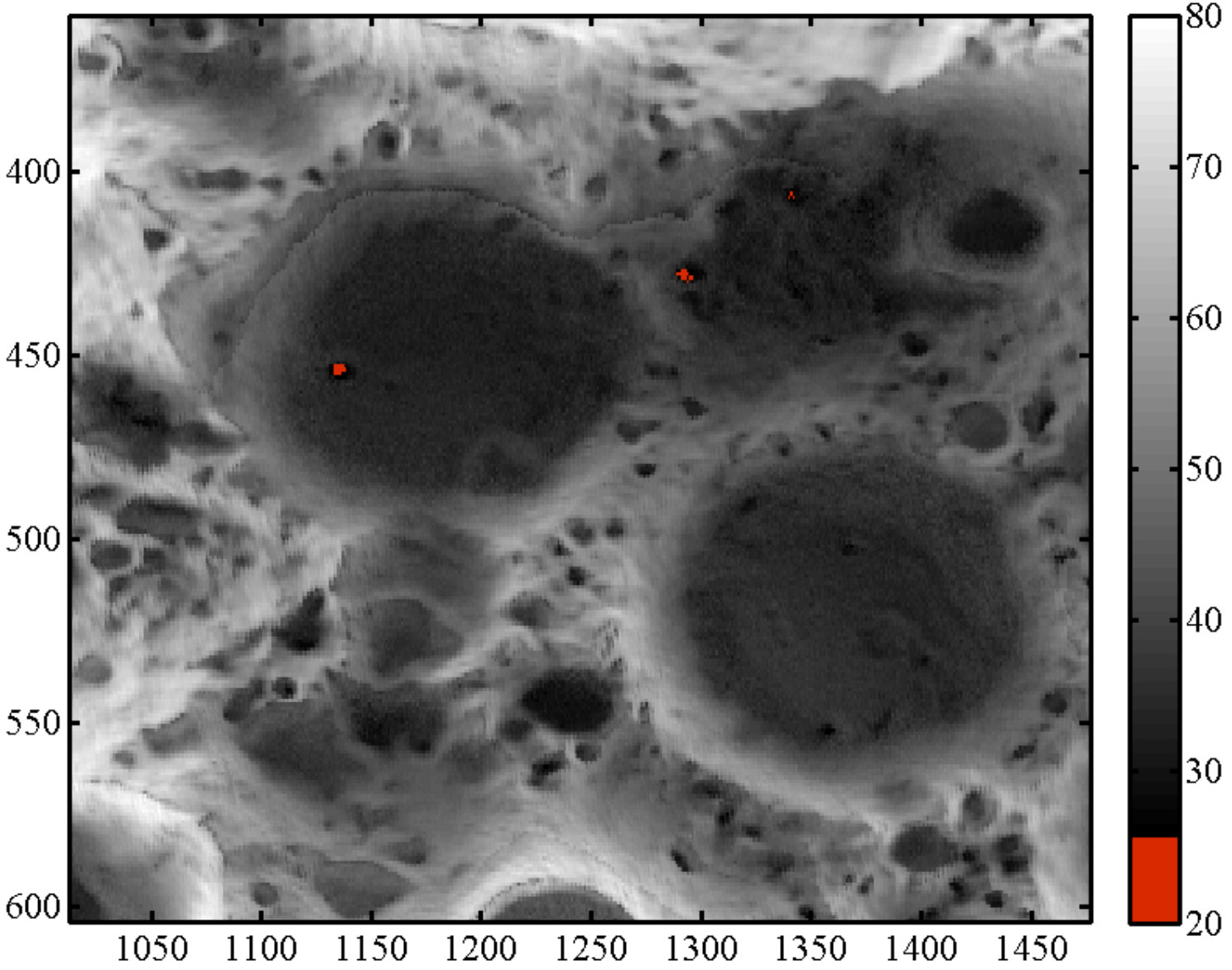
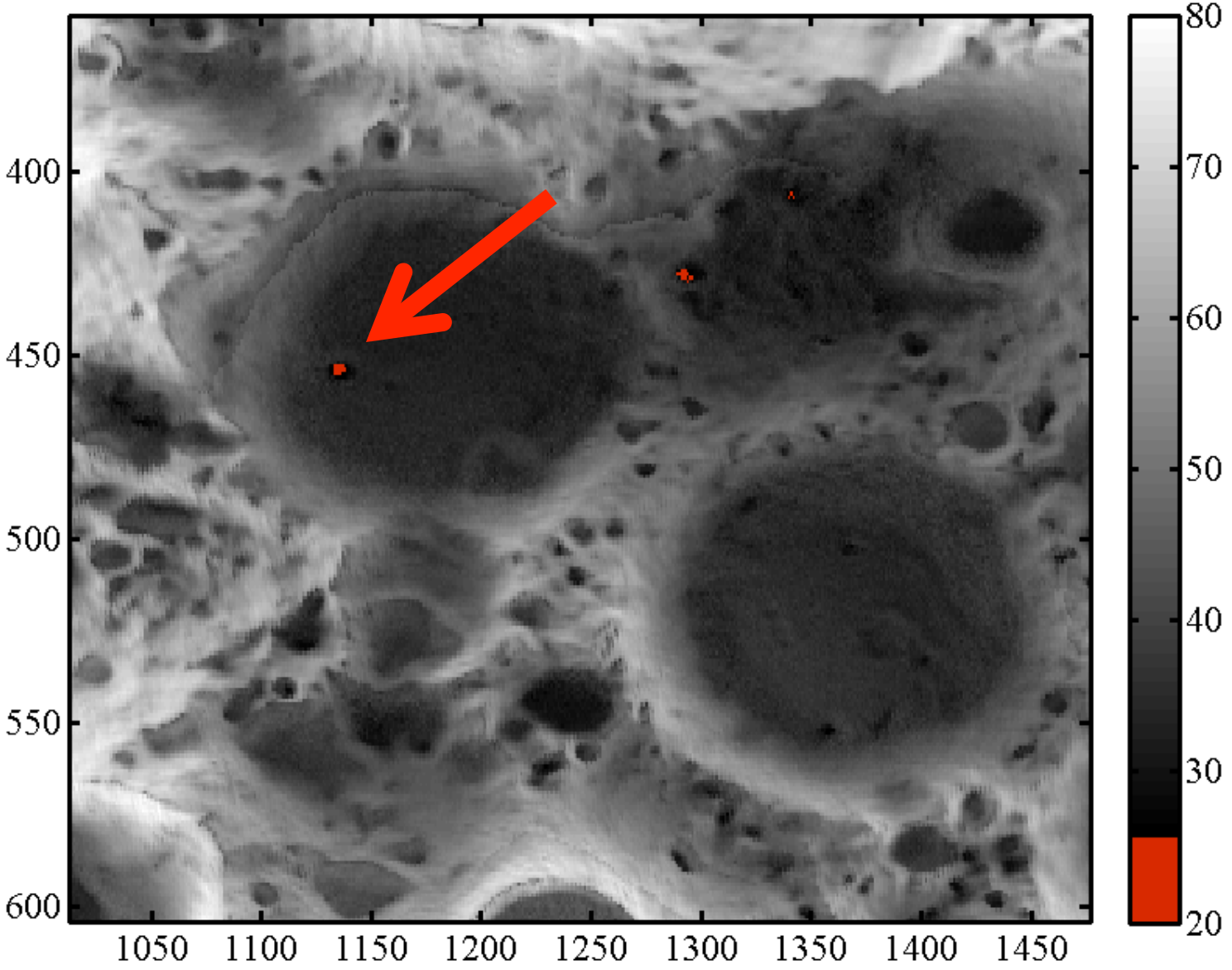
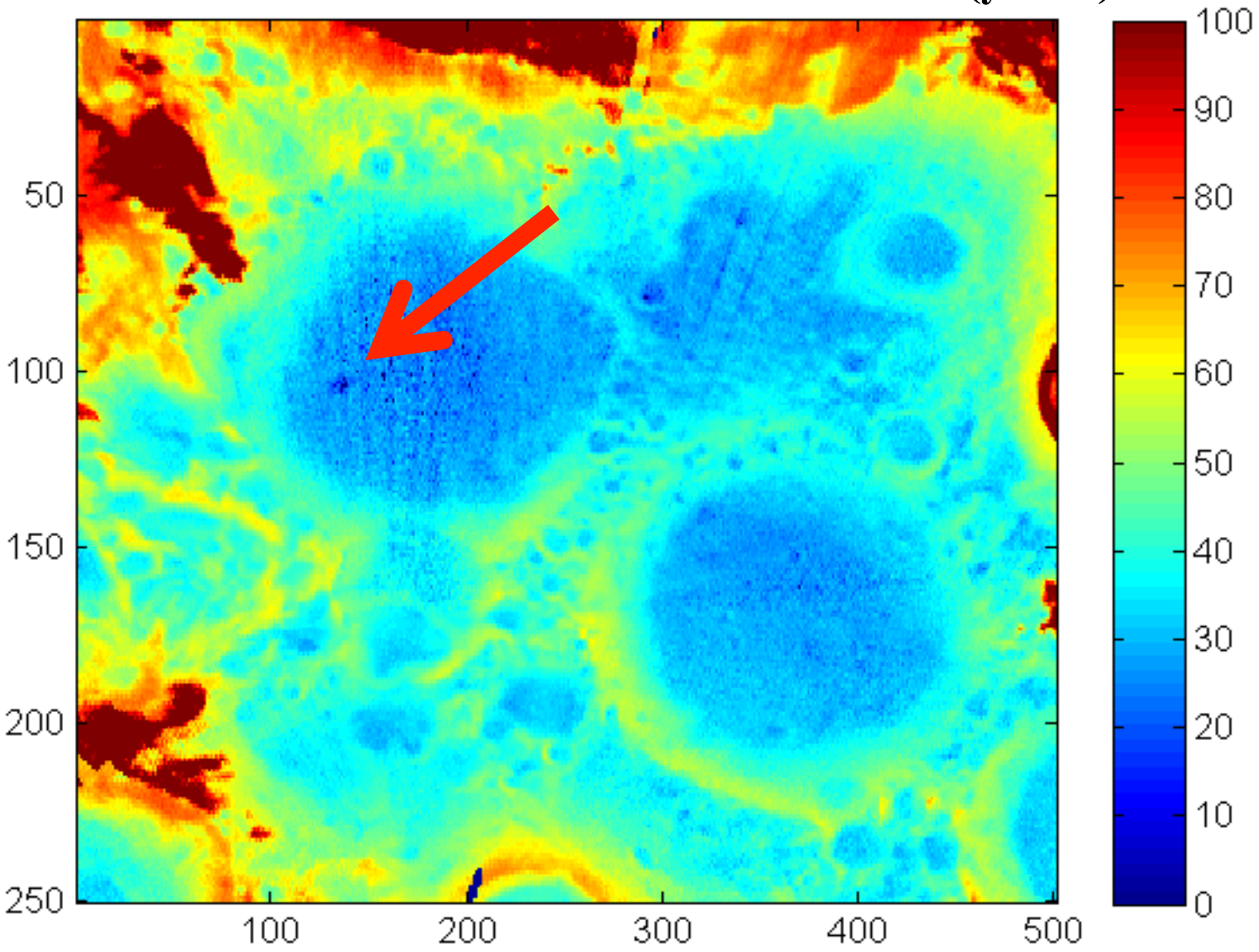
Model Minimum below 25K



Model Minimum below 25K

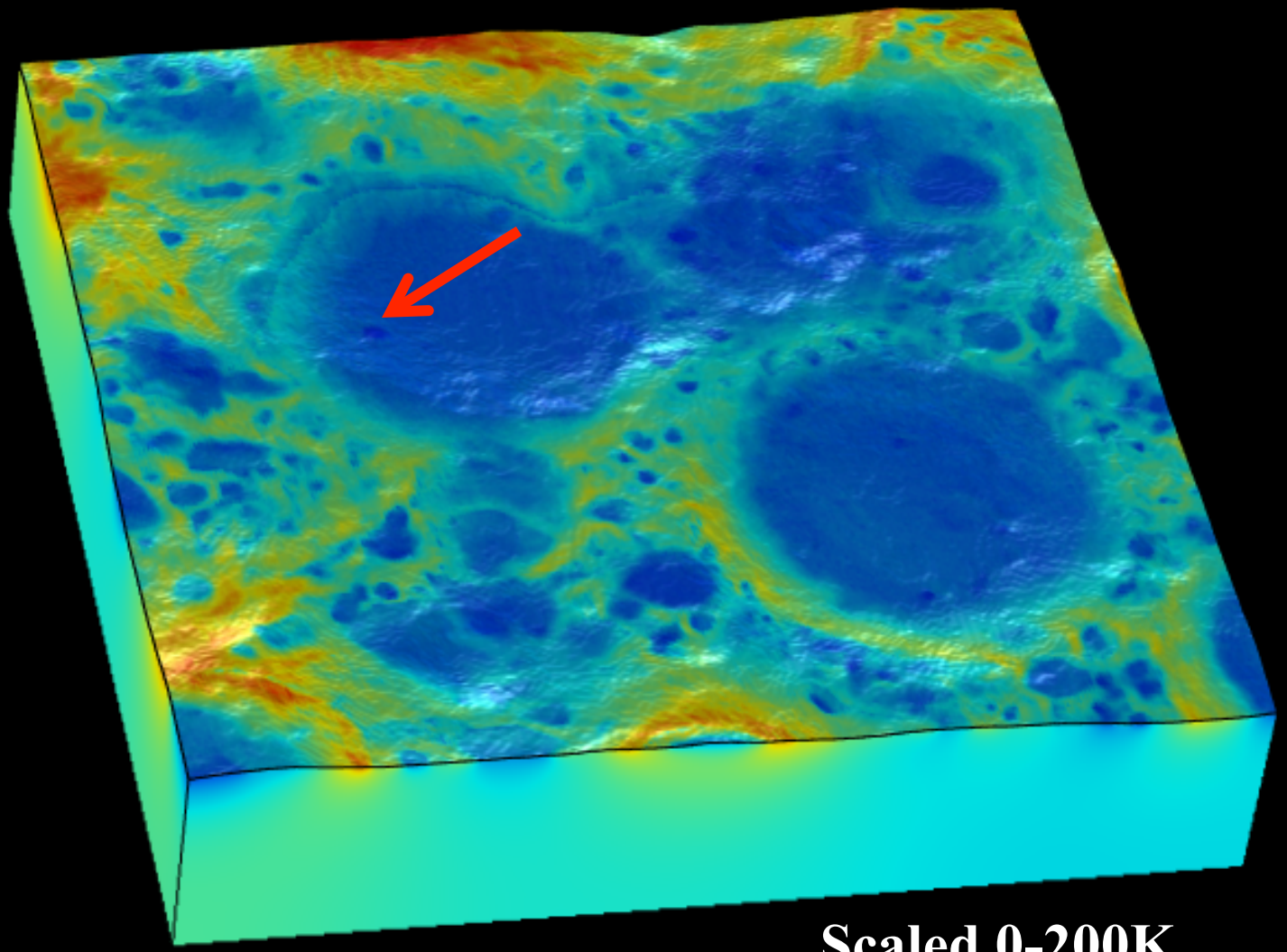


Diviner Data from Southern Winter Solstice (year 2)



2) Data in Cold Places

Model mean T

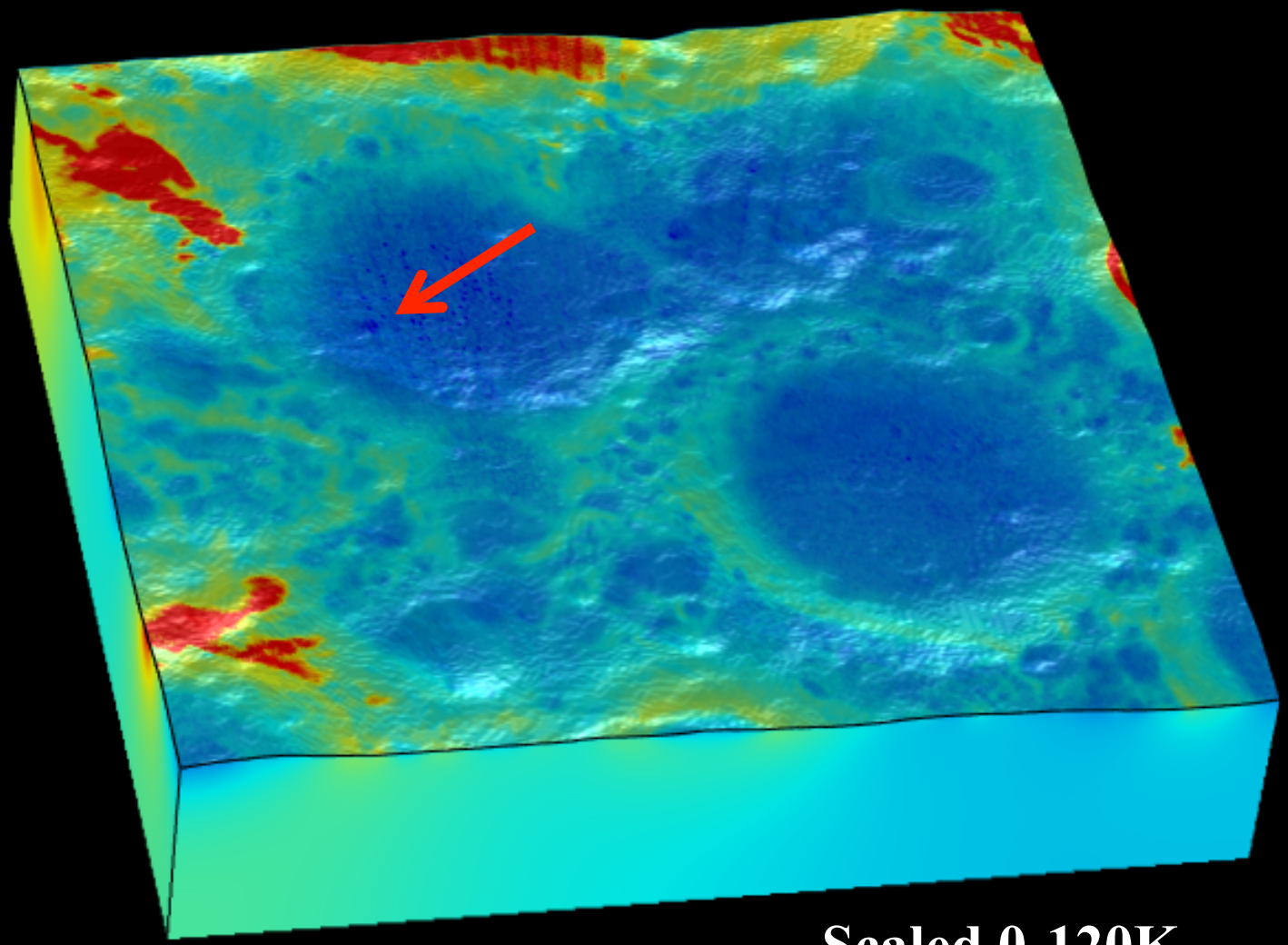


Scaled 0-200K

3D model in COMSOL

2) Data in Cold Places

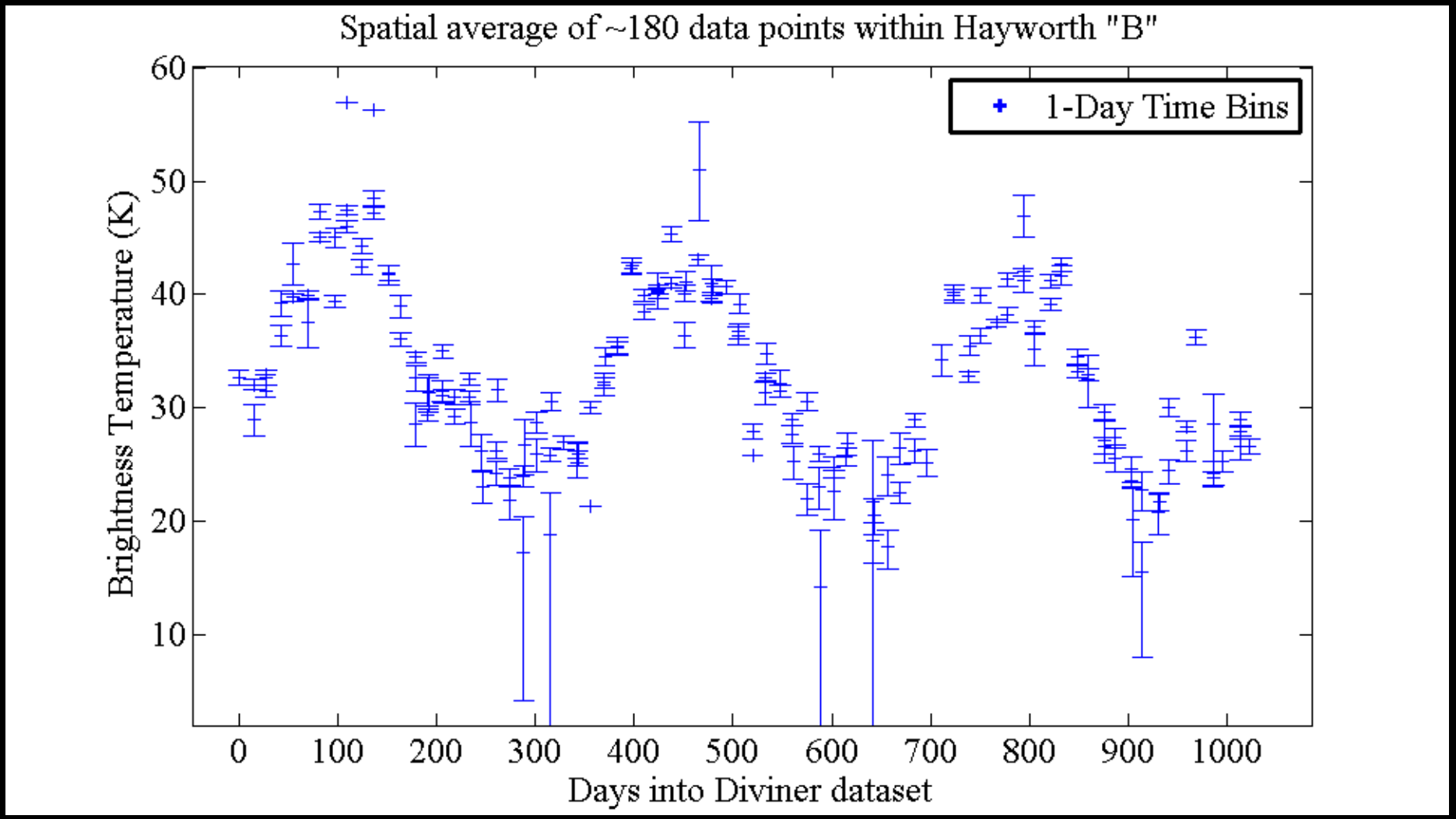
Data (Winter Solstice)



Scaled 0-120K

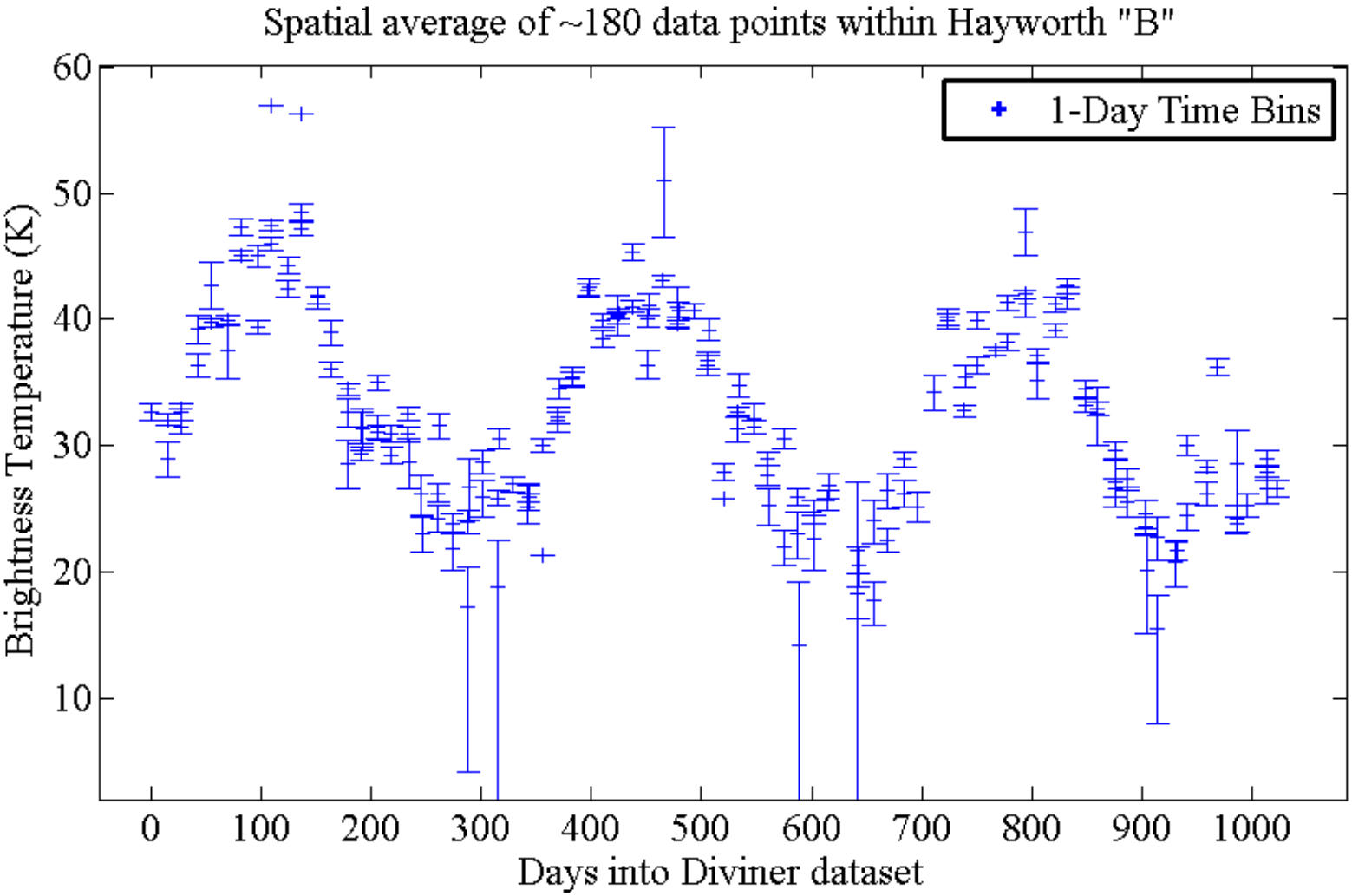
3D model in COMSOL

2) Data in Cold Places



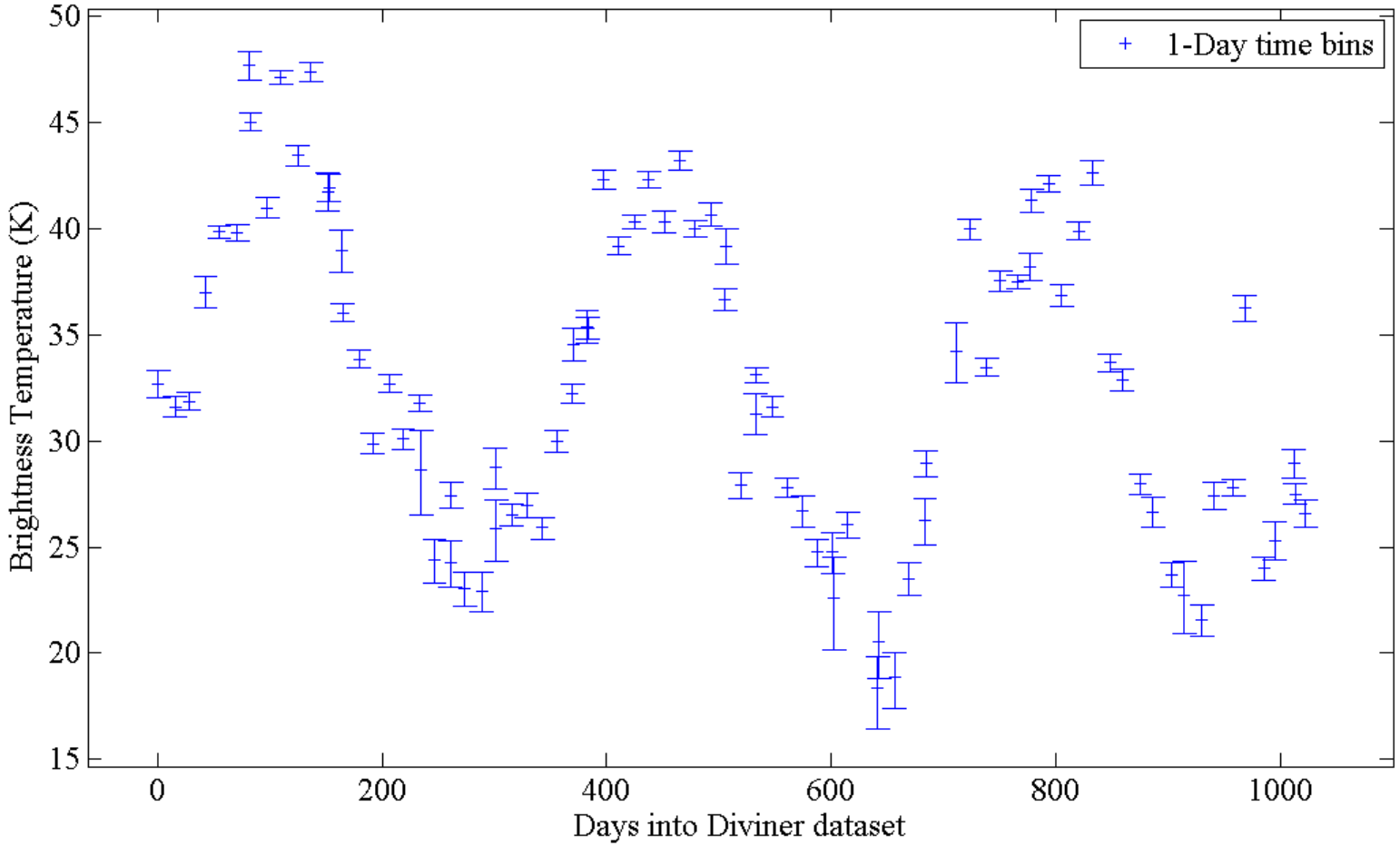
2) Data in Cold Places

Damn, that's cold!



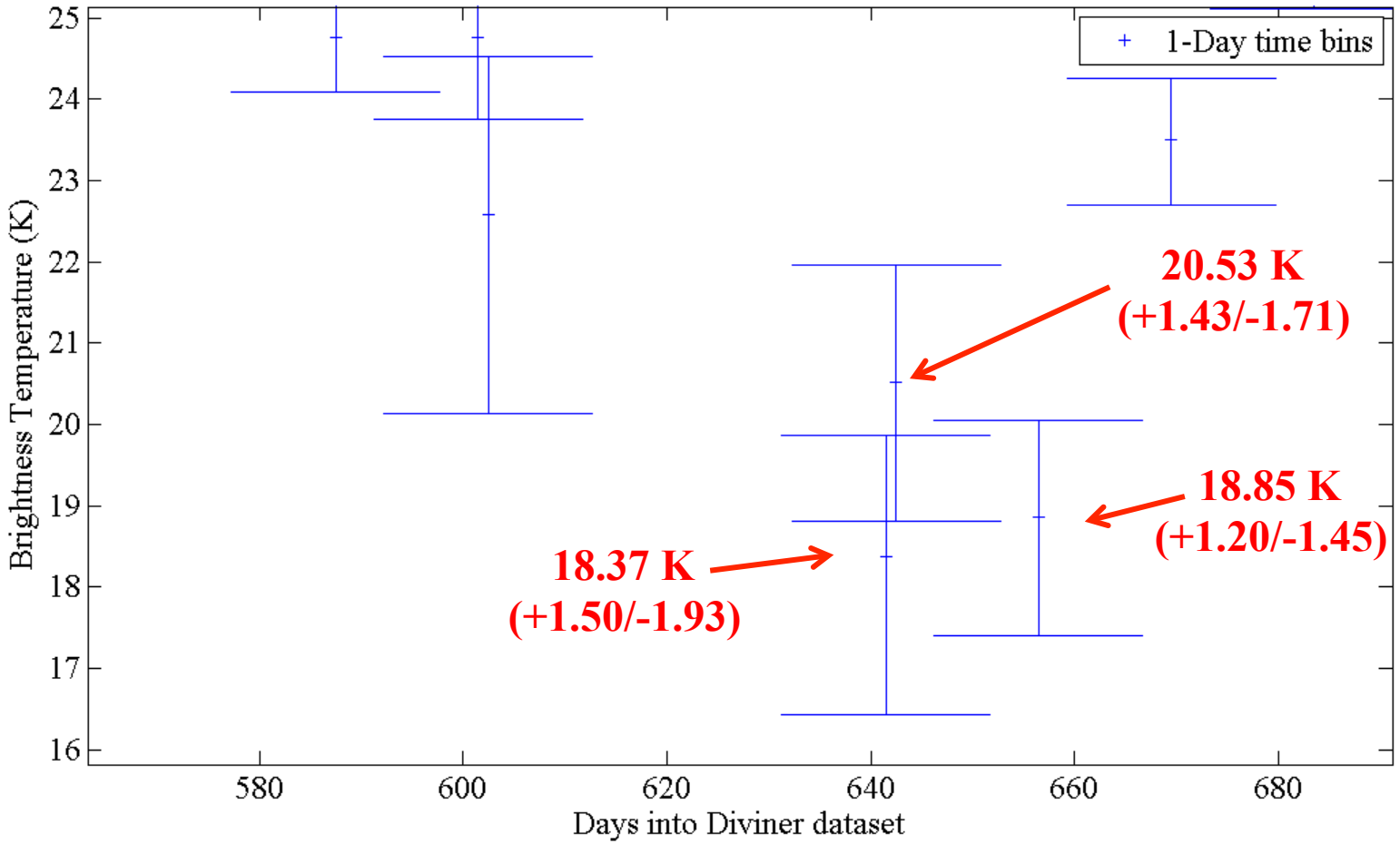
2) Data in Cold Places

How cold is it ?



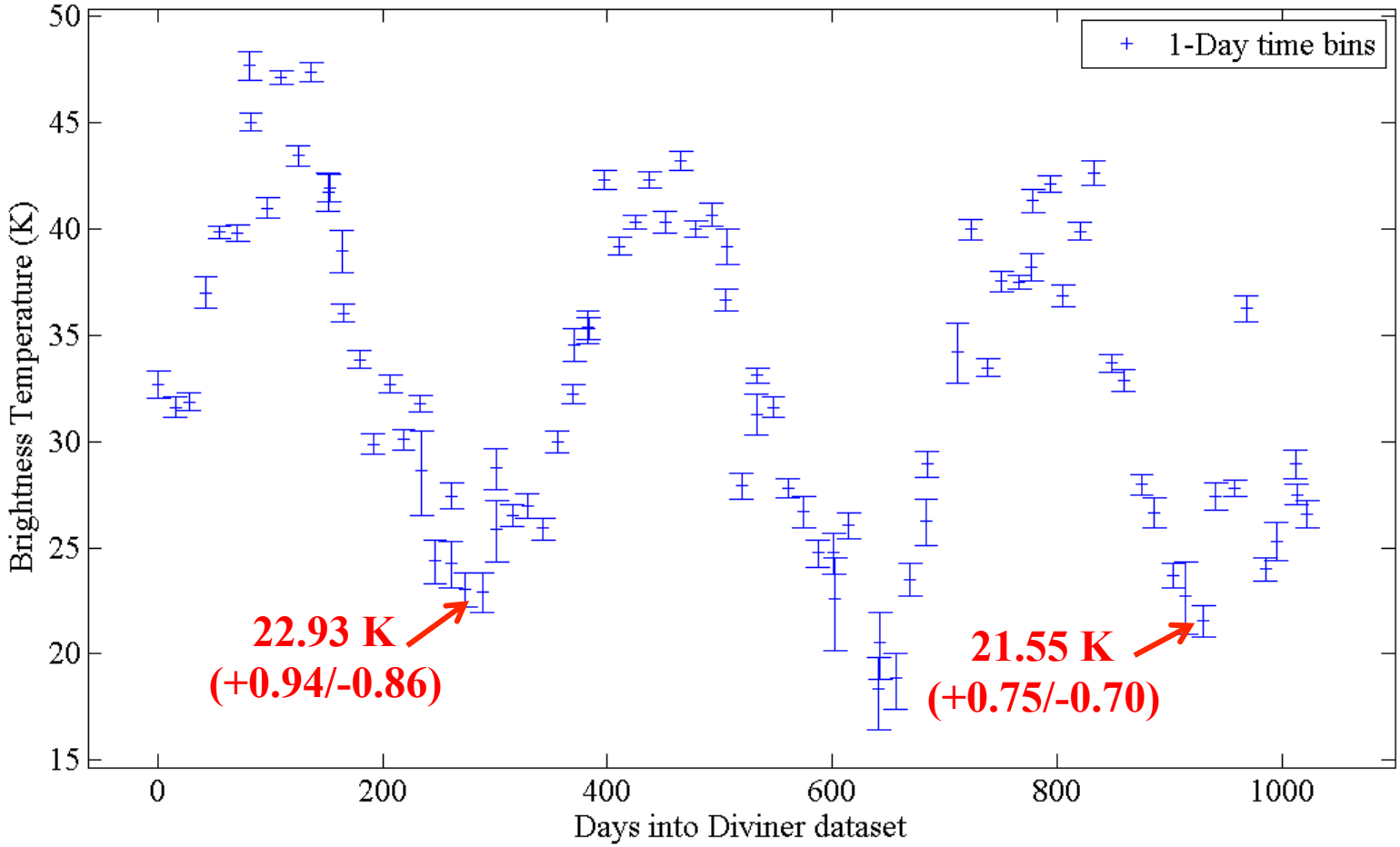
2) Data in Cold Places

How cold is it ?



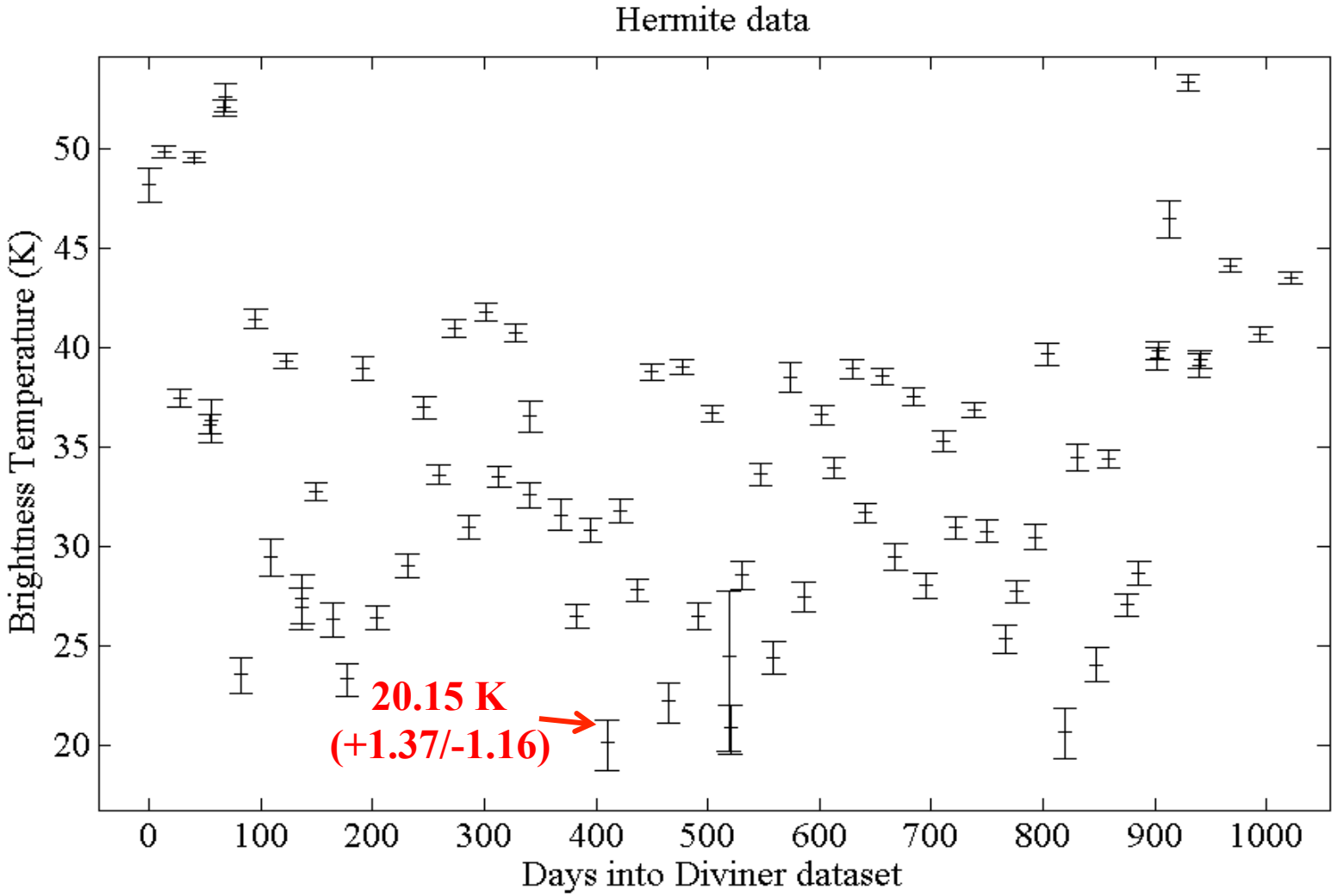
2) Data in Cold Places

Just in case you don't believe that…



2) Data in Cold Places

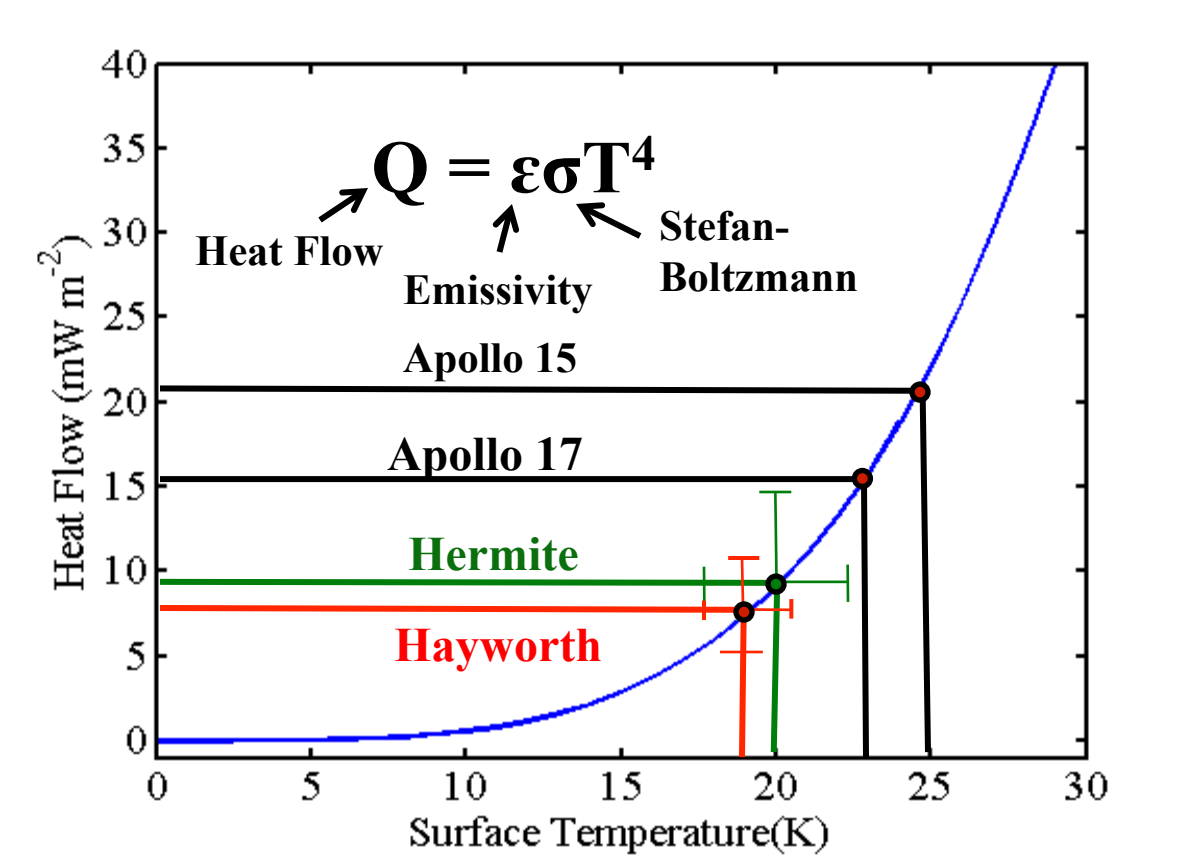
This beats (or at least matches) the previous record



… and frankly the insolation pattern is less complicated

3) What does this mean?

Assuming no scattered light is reaching the surface (and unit emissivity)this gives us an upper limit on lunar heat flow.



This is consistent with lower heat flux away from KREEP

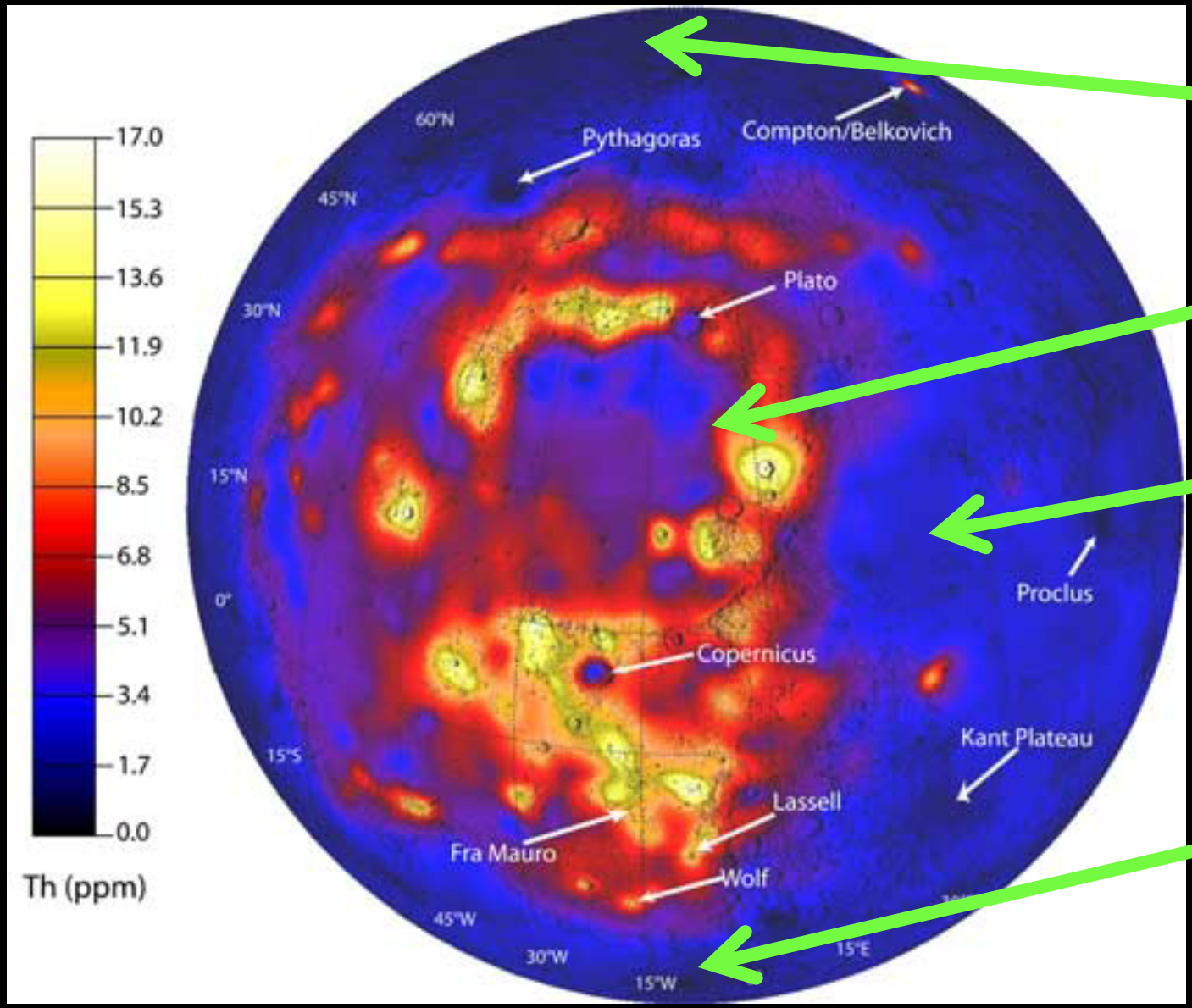
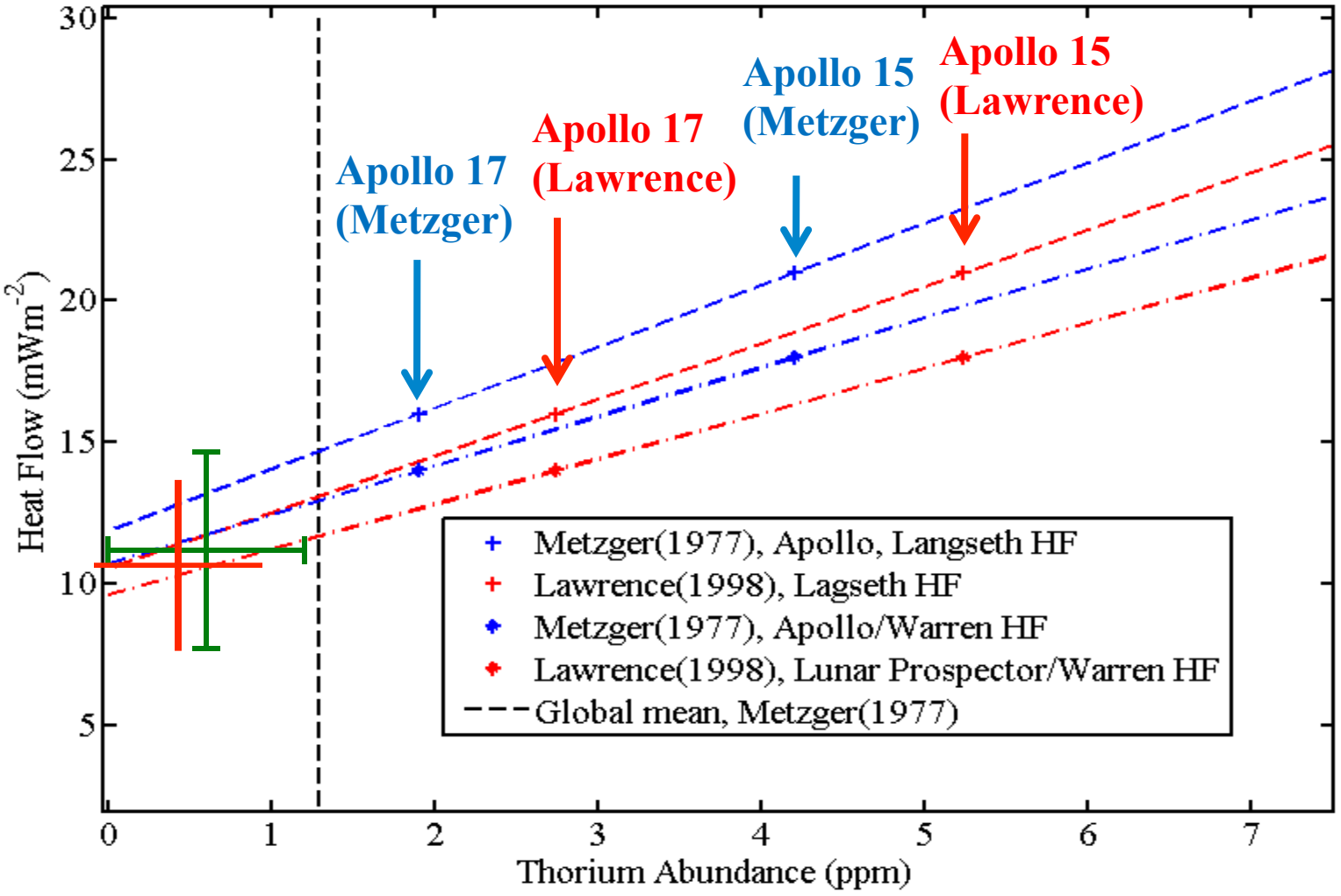


Image from Lawrence et al. (2007)

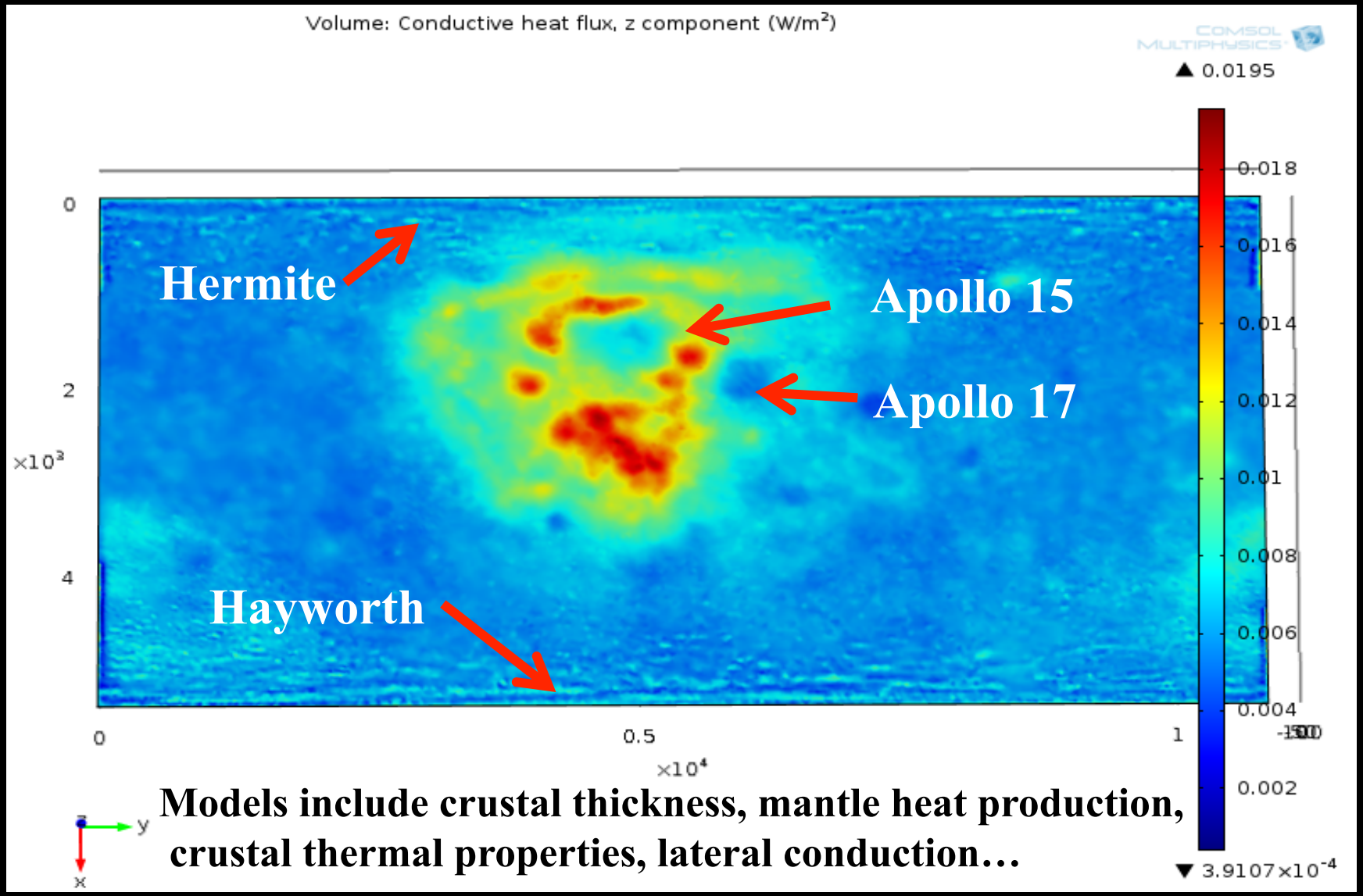
3) What does this mean?

And simple models relating Throium to heat flux



4) Attack

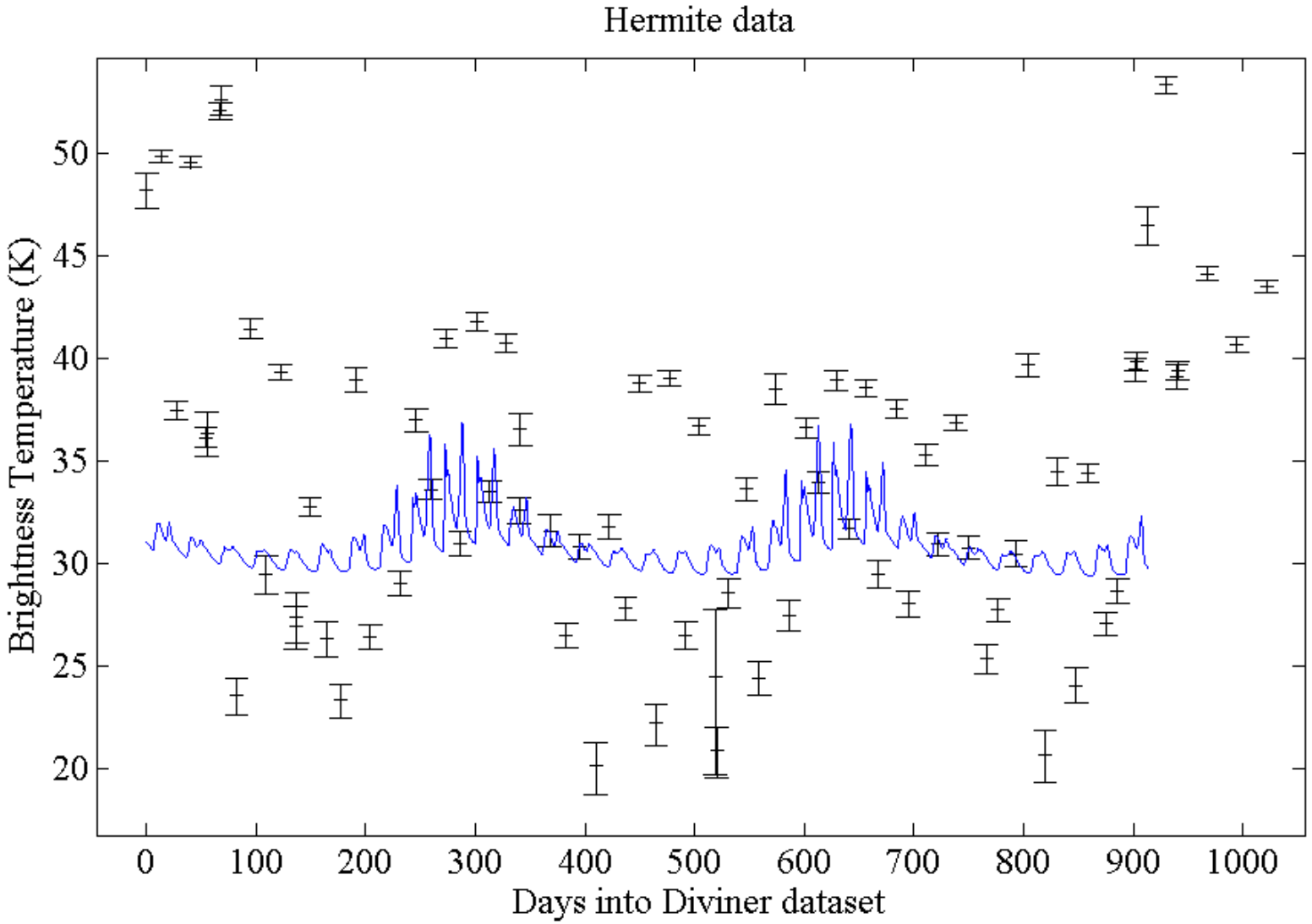
New models of 3D radioisotope distributions in COMSOL aiming to get best fit global distribution



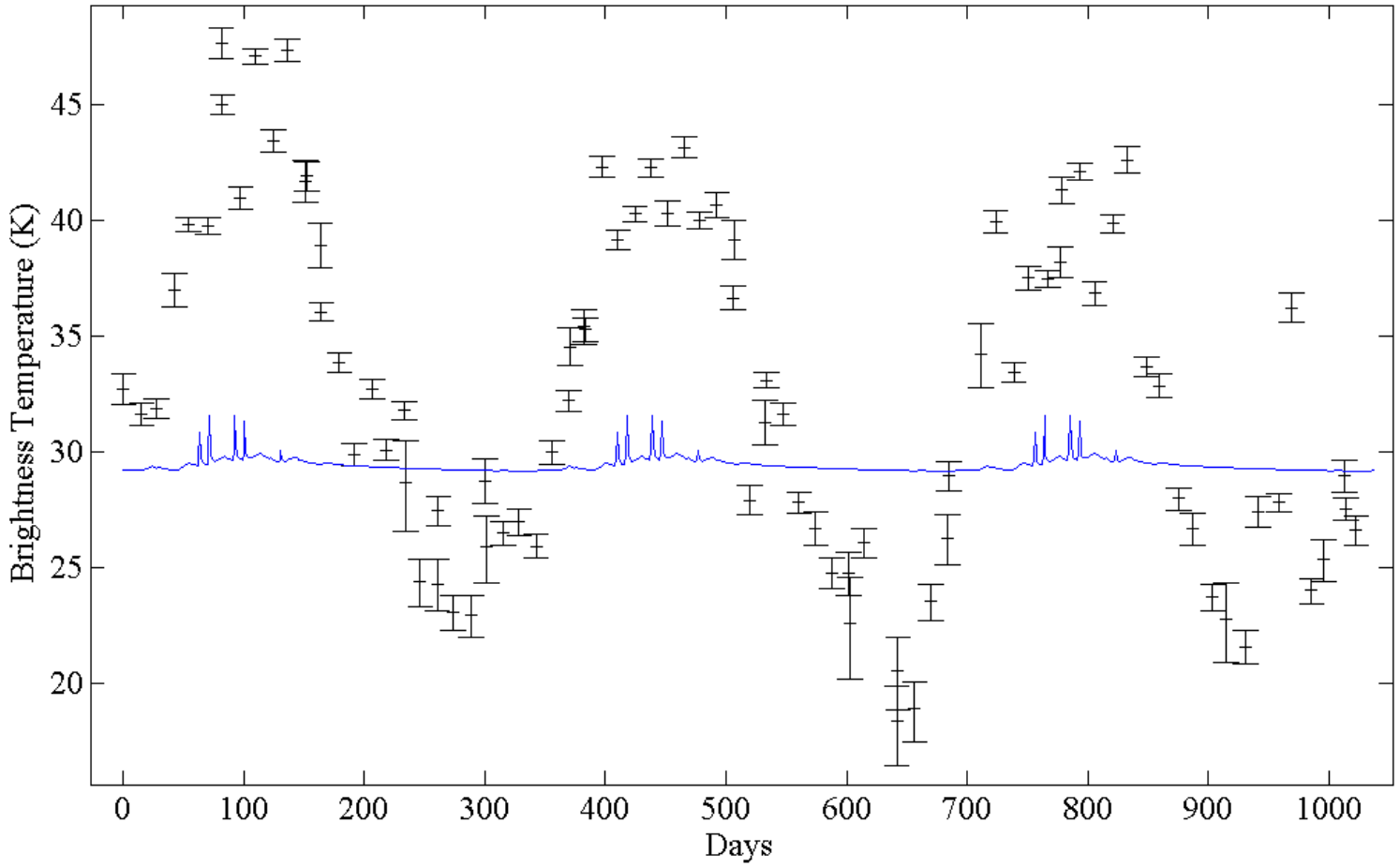
Models include crustal thickness, mantle heat production, crustal thermal properties, lateral conduction…

4) Attack

But constraining models comes back to the data…

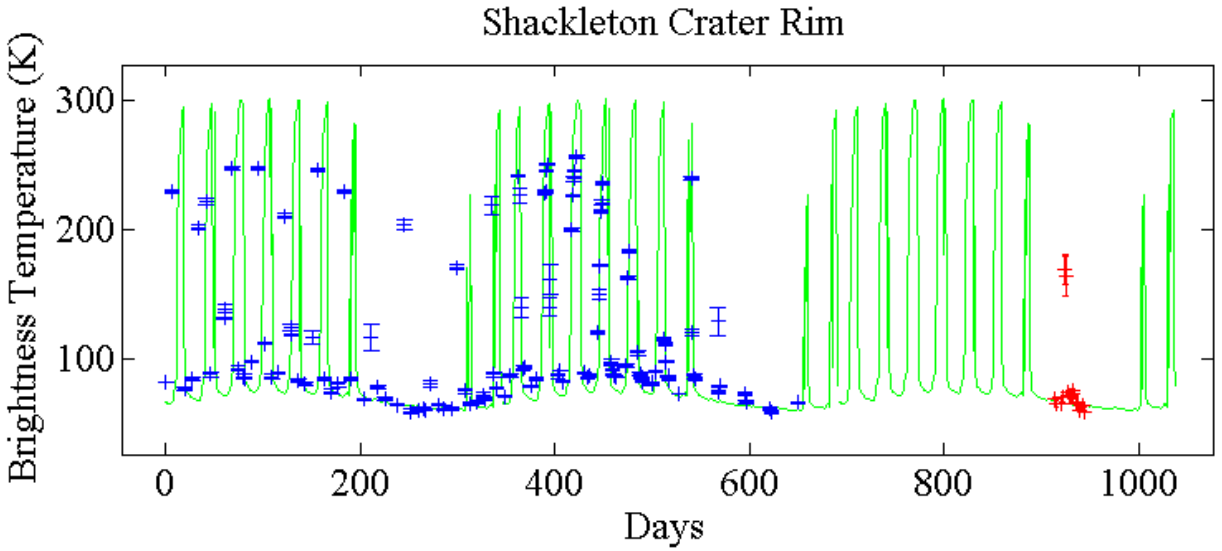


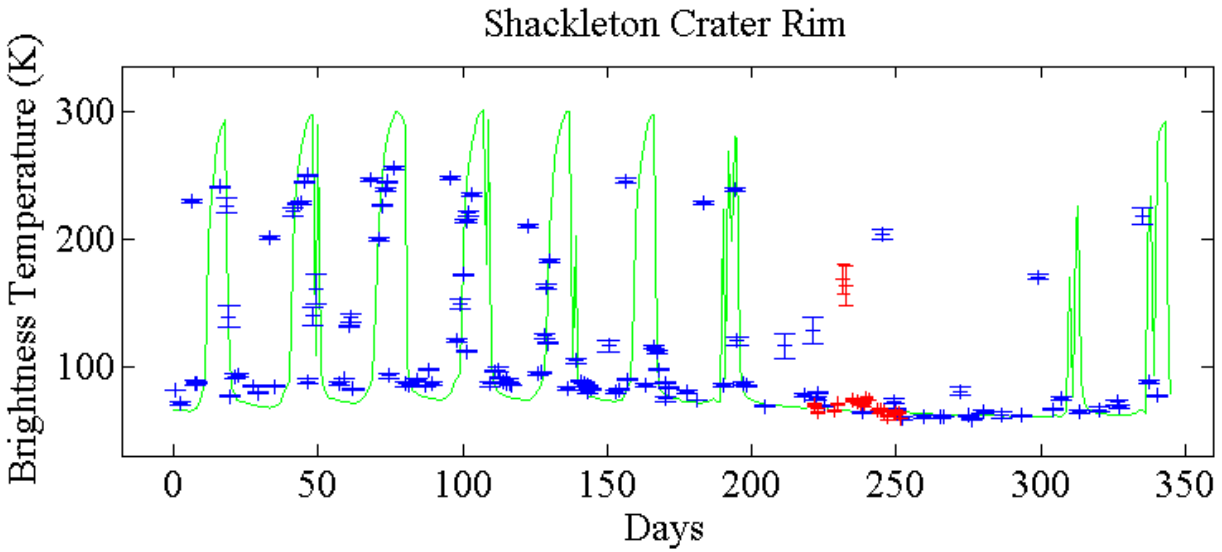
In both cases data is very different from our model - demanding very low thermal inertia



4) Attack

Warmer places do not share this issue





4) Attack

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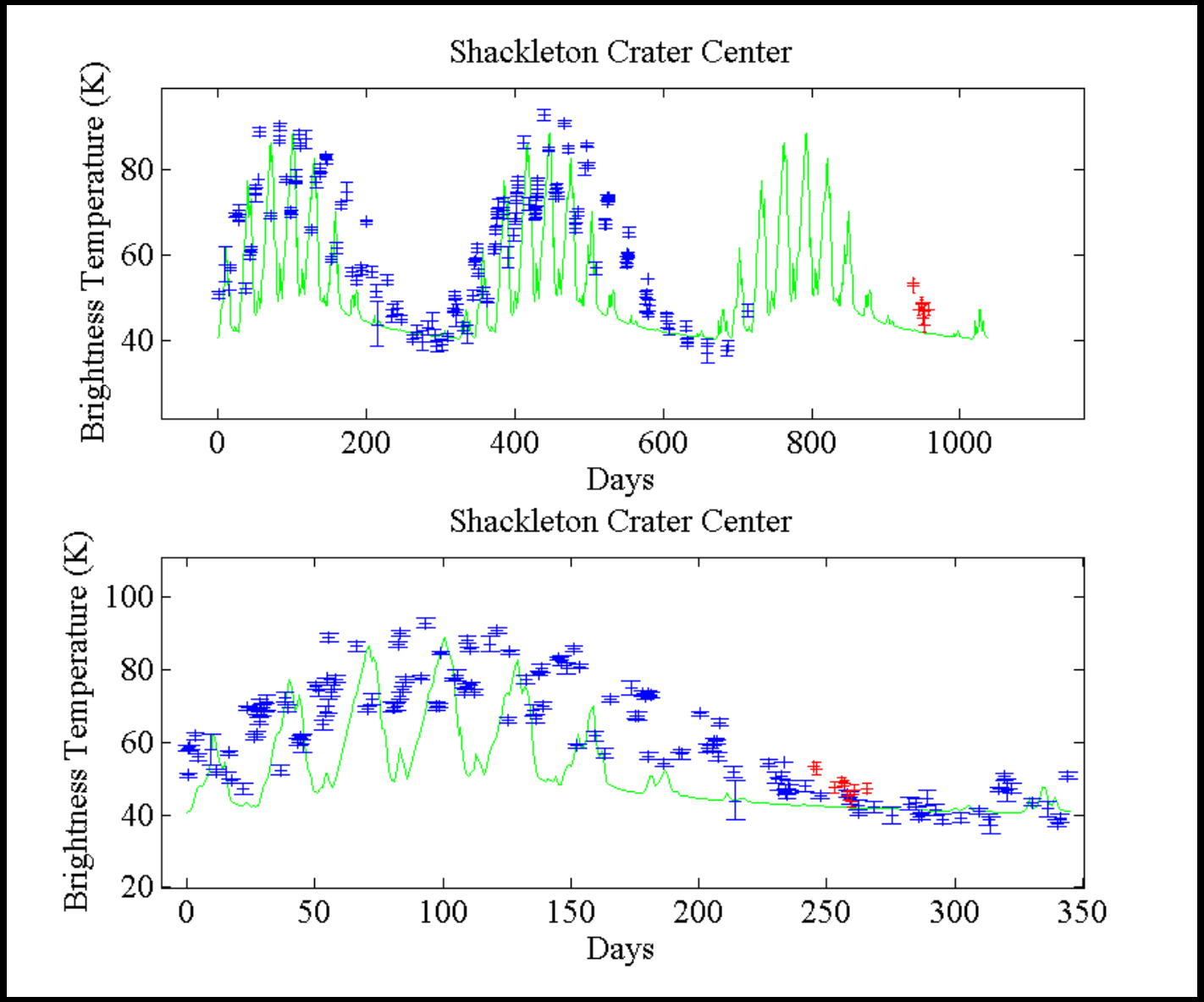
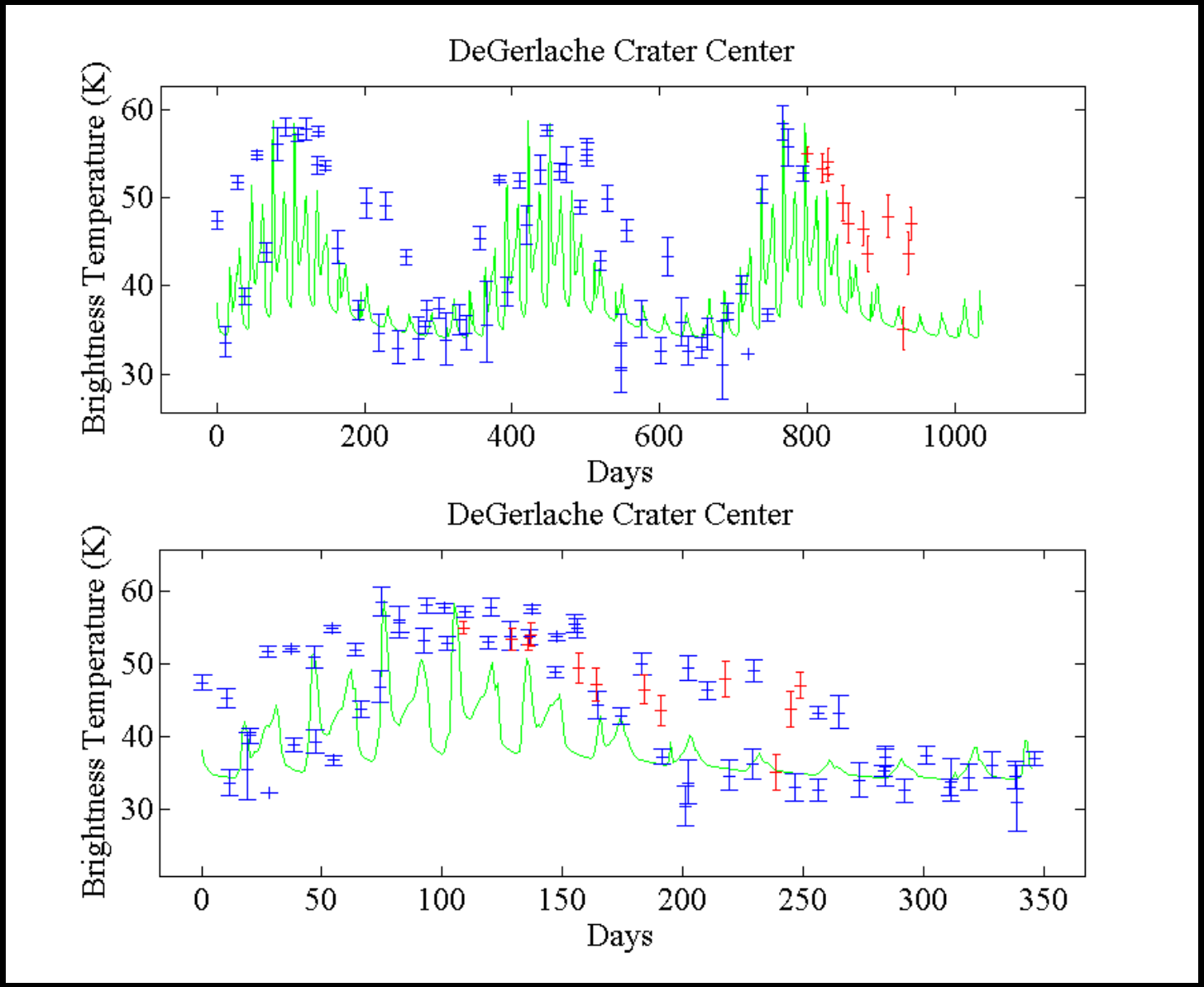
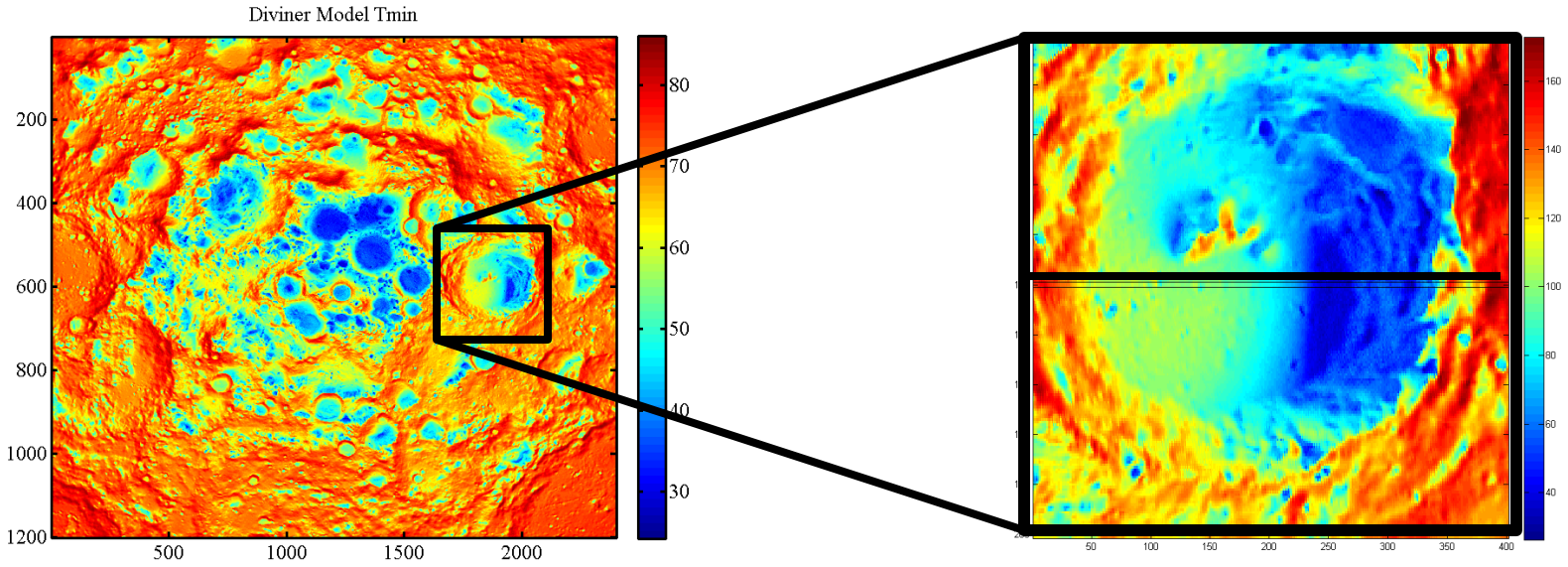
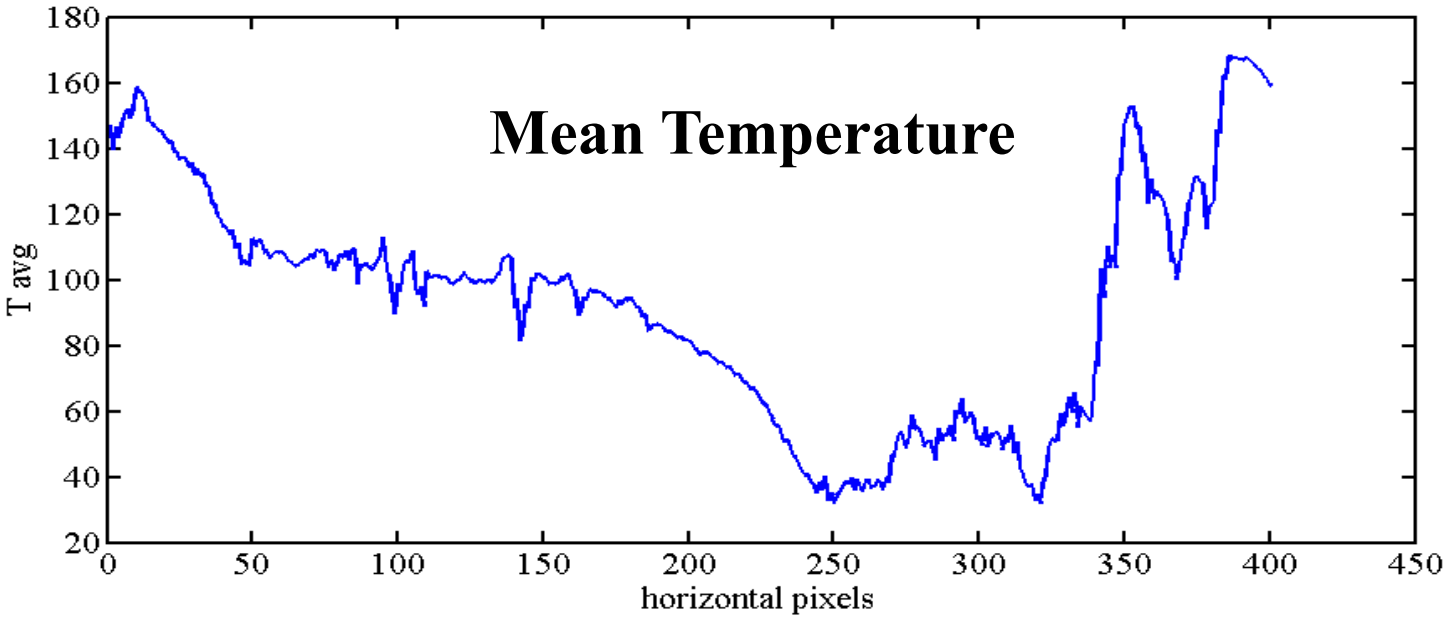


Data/model discrepancy seems to grow with decreasing T



Amundsen Crater as a temperature laboratory





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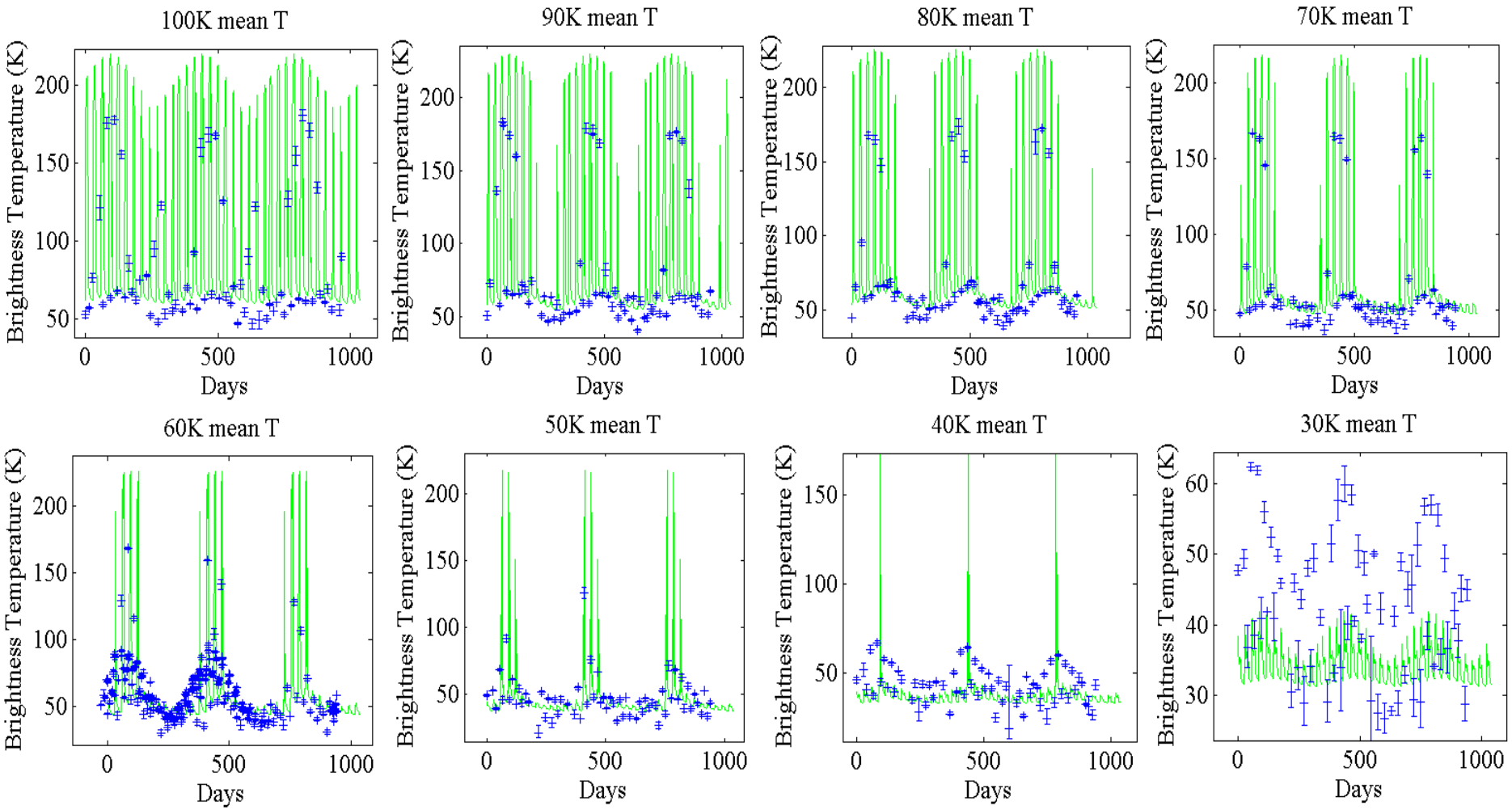
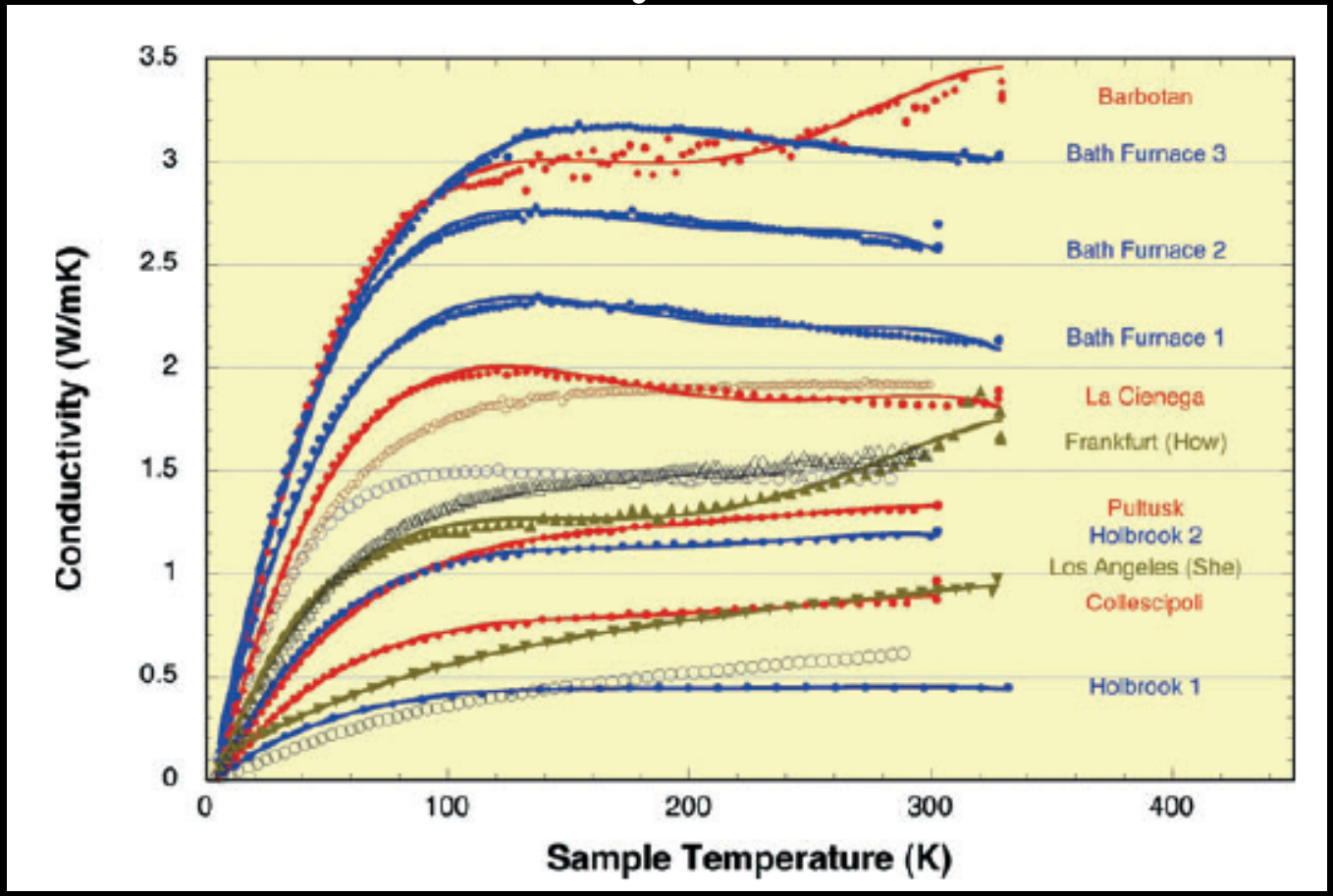


This may be due to temperature dependent thermal conductivity seen in Lab

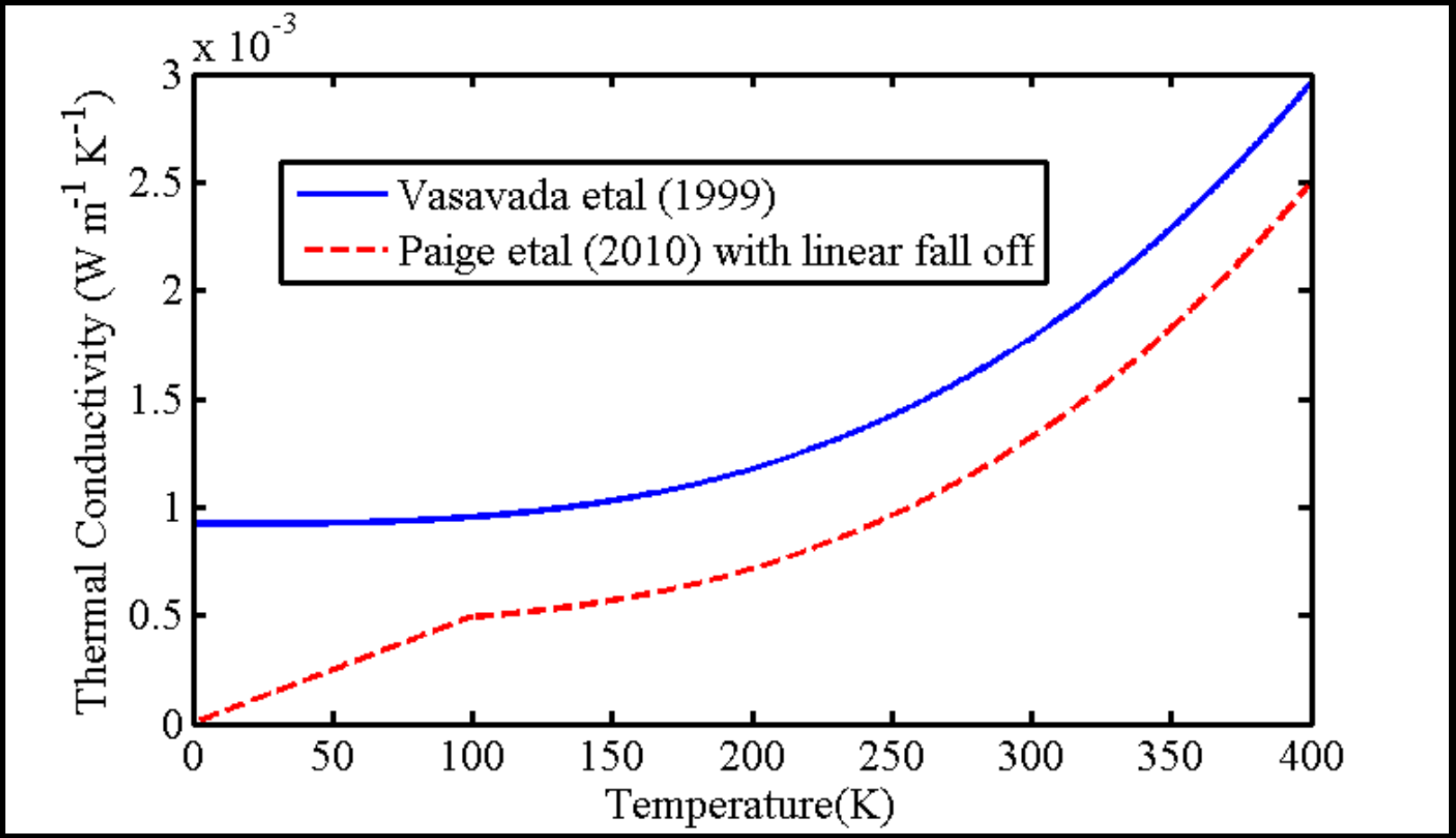


Stony meteorite thermal properties and their relationship with meteorite chemical and physical states

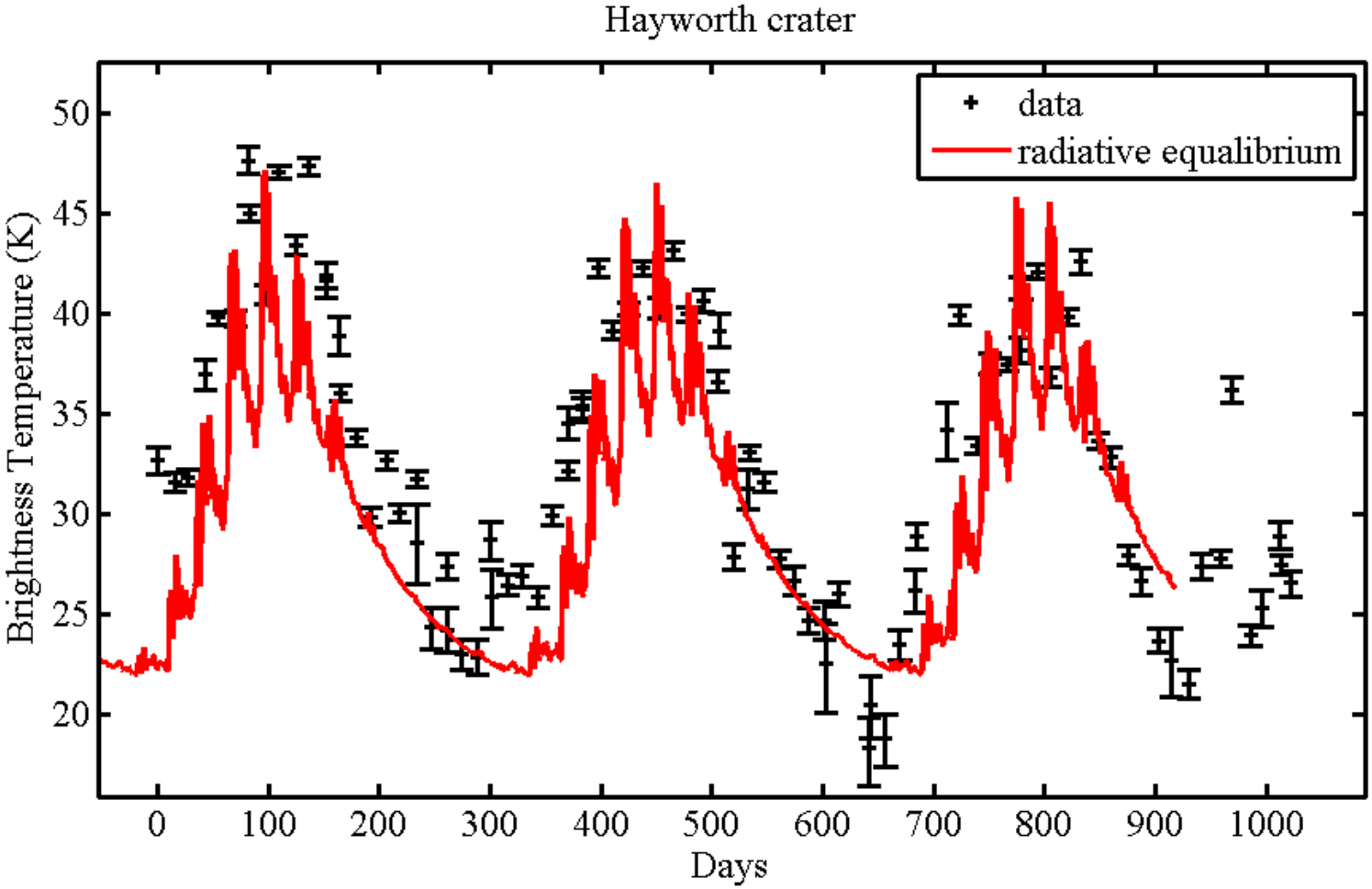
C. P. OPEIL SJ[1], G. J. CONSOLMAGNO SJ[2*], D. J. SAFARIK[3], and D. T. BRITT[4]

Meteoritics & Planetary Science 47, Nr 3, 319–329 (2012)
doi: 10.1111/j.1945-5100.2012.01331.x

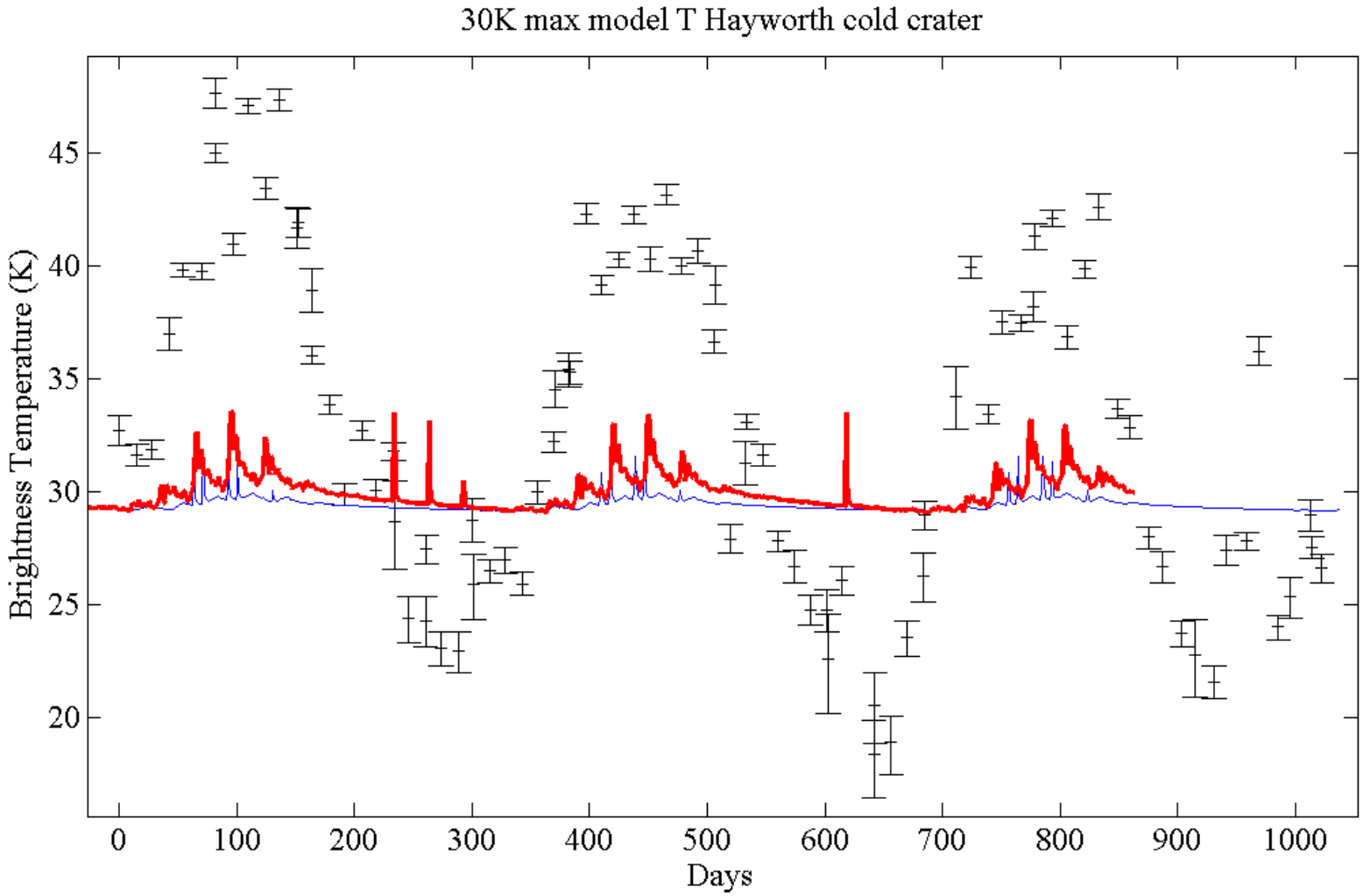
Faking that trend with a linear fall off (and factor of 2 thermal conductivity decrease)…



Assuming zero thermal inertia (and zero albedo)

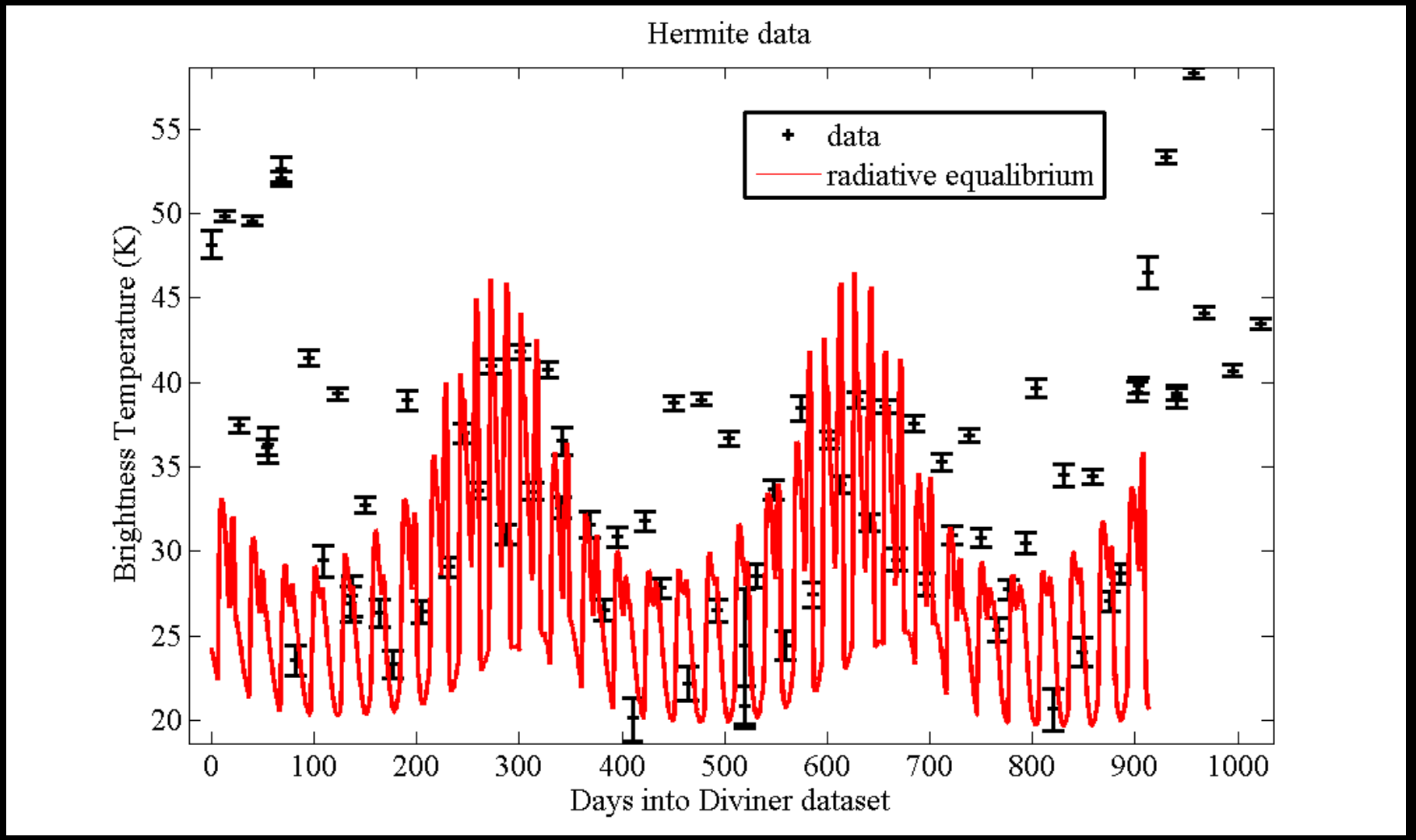


…better, but still not great…

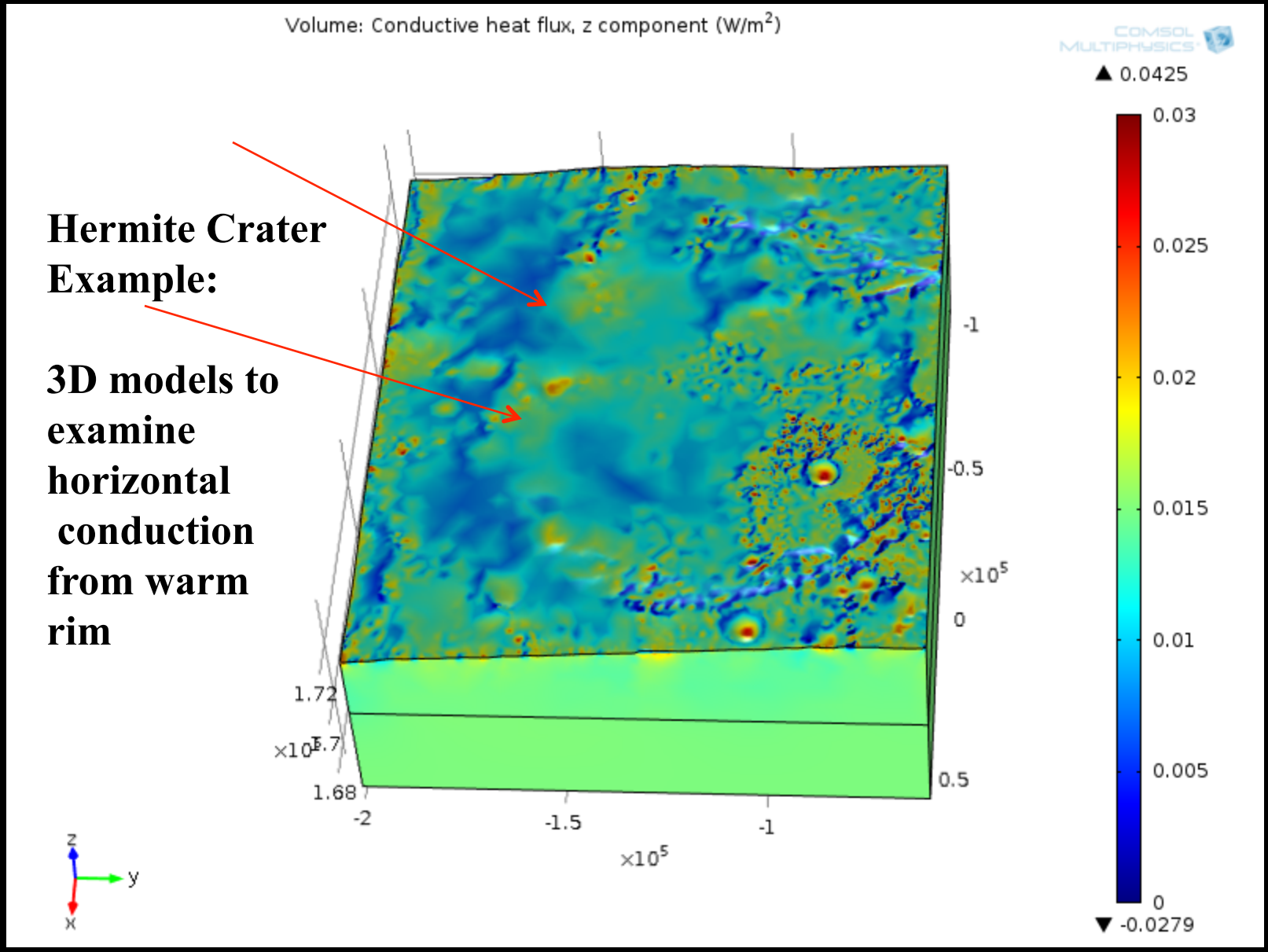


Note: last minute concerns about this model have come up….

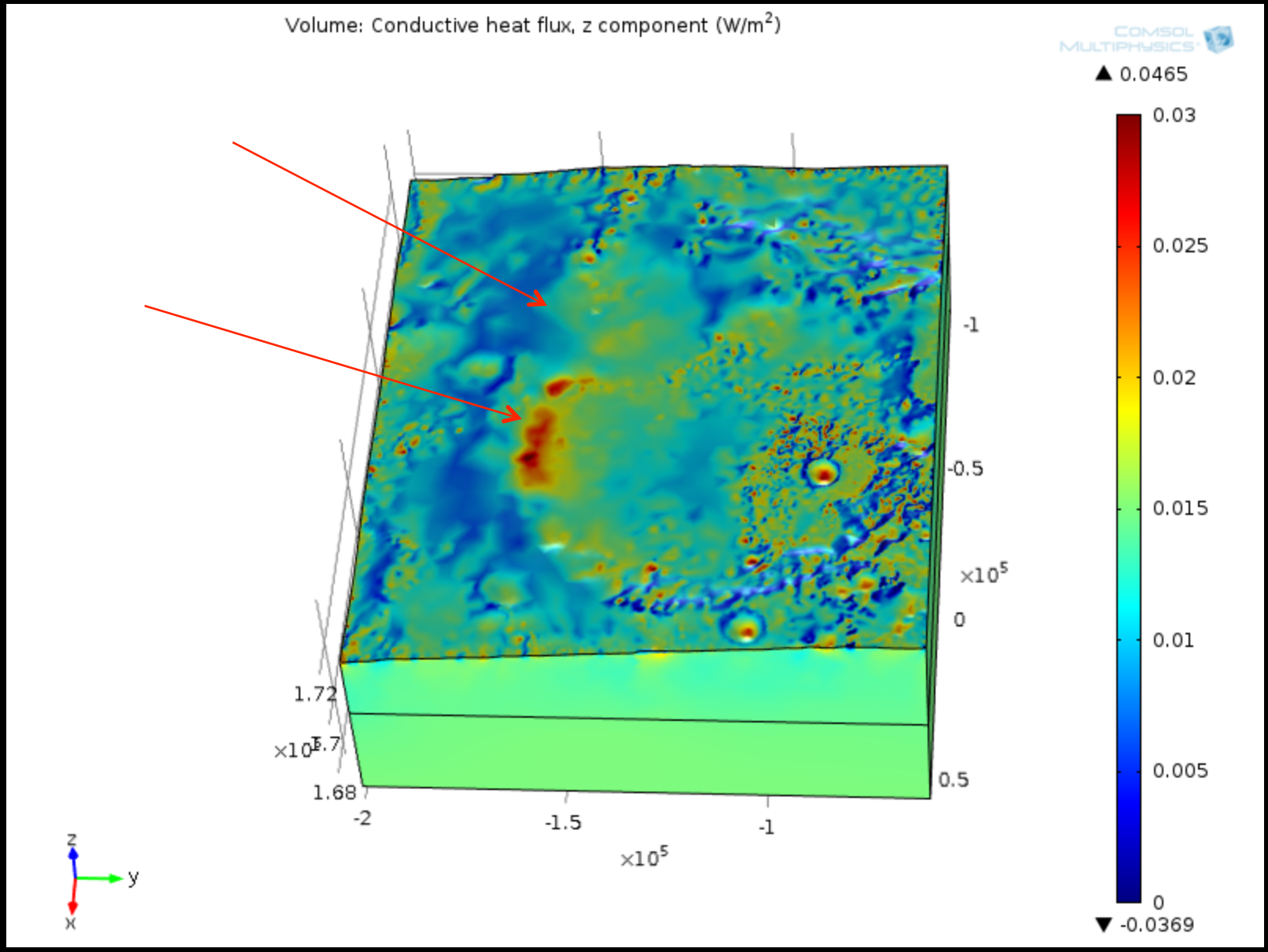
Assuming zero thermal inertia (and zero albedo)



I'll conclude there… but much more to come…



3km thick disc



5km thick disc